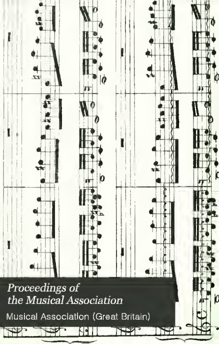
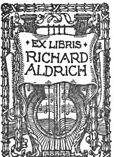


Proceedings of the Musical Association

Musical Association (Great Britain)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PROCEEDINGS

OF THE

MUSICAL ASSOCIATION

FOR THE INVESTIGATION AND
DISCUSSION OF SUBJECTS CONNECTED WITH THE
ART AND SCIENCE OF MUSIC

FOUNDED MAY 29, 1874

FIRST SESSION, 1874-75

Printed by
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1875

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Musical Association

FOR THE

INVESTIGATION AND DISCUSSION OF SUBJECTS

CONNECTED WITH

THE ART AND SCIENCE OF MUSIC.

1874.

THE following letter, addressed by William Spottiswoode, Esq., M.A., F.R.S., to some leading Members of the Musical and Scientific World, originated this Association:

'50 GROSVENOR PLACE:
'8th April, 1874.

'DEAR SIR,—It has been suggested by several leading persons interested both in the theory and practice of Music, that the formation of a Society, similar in the main features of its organisation to existing Learned Societies, would be a great public benefit. Such a Musical Society might comprise among its members the foremost Musicians, theoretical as well as practical, of the day; the principal Patrons of Art; and also those Scientific men whose researches have been directed to the science of Acoustics and to kindred inquiries. Its periodical meetings might be devoted partly to the reading of Papers upon the history, the principles, and the criticism of Music; partly to the illustration of such Papers by actual performance; and partly to the exhibition and discussion of experiments relating to theory and construction of musical instruments, or to the principles and combination of musical sounds.

With a view to ascertain the opinions of persons interested in these subjects, and to attempt a more precise definition of the objects and constitution of such a Society, it is proposed to hold a meeting here, at which your presence is requested, on Thursday, April 16th, at 2.30 p.m.

I am, Dear Sir, yours faithfully,
W. SPOTTISWOODE."

A meeting took place at the residence of Mr. Spottiswoode, when the objects of the suggested Society were discussed, and a Committee was appointed.

Another meeting was held, by permission, in the Board-room of the South Kensington Museum, on Friday, May 29th, 1874, John Hullah, Esq., in the chair, when several gentlemen enrolled themselves as Original Members of the new Society, and rules were determined upon.

On Tuesday the 4th of August following, a General Meeting of the Members was held at 36 Baker Street, Portman Square, the residence of Charles Kensington Salaman, Esq., a member of the Committee and Honorary Secretary—Alexander John Ellis, Esq., F.R.S., in the chair; when, after much discussion as to the permanent title of the Society, it was resolved that it should be thus named:—

MUSICAL ASSOCIATION, FOR THE INVESTIGATION AND DISCUSSION OF SUBJECTS CONNECTED WITH THE ART AND SCIENCE OF MUSIC.

RULES.

1. This Association is intended to be similar in its organisation to existing Learned Societies.

2. The Members will consist of practical and theoretical Musicians, as well as those whose researches have been directed to the science of Acoustics, the history of Music, or other kindred subjects.

3. The Association will hold its meetings on the first Monday of every month, from November to June, at five o'clock p.m., when papers will be read and discussed as at other Learned Societies. These papers may treat of any subject connected with the Art or Science of Music.

4. Experiments and performances may be introduced, when strictly limited to the illustration of the Papers read.

5. Papers and Communications will be received from, or through, any Member of the Association.

6. Reports of the Proceedings will be distributed to the Members, and will be published.

7. It is not intended that the Association shall give Concerts, or undertake any publications other than those of their own Proceedings, and the Papers read at their meetings.

8. The Election of Members will be by Ballot.

9. The management will be vested in a Committee, to be annually elected by the Members of the Association.

10. The annual subscription to the Association is One Guinea.[1]

CHARLES K. SALAMAN, *Hon. Sec.*

[1] Payable to Messrs. Chappell, 50 New Bond Street, W., on or before the first Monday in November.

SESSIONAL ARRANGEMENTS.

1874–5.

First Meeting—Monday, November 2nd, 1874:

Paper by Dr. W. H. Stone, M.A., F.R.C.P., 'On Extending the Compass and Increasing the Tone of Stringed Instruments.' (Illustrated.)

Paper by R. H. M. Bosanquet, Esq., M.A., Fellow of St. John's Coll., Oxon, F.R.A.S., F.C.S., 'On Temperament; or, The Division of the Octave.' First Part. (Illustrated.)

Second Meeting—Monday, December 7th, 1874:

Paper by Sedley Taylor, Esq., M.A., Trin. Coll., Camb., On a Suggested Simplification of the Established Pitch-Notation.'

Alexander John Ellis, Esq., F.R.S., will exhibit a Mesotonic Harmonium, playing from seven flats to seven sharps, by a new stop-action.

Third Meeting—Monday, January 4th, 1875:

Paper by J. Baillie-Hamilton, Esq., 'On the Application of Wind to String Instruments.' (Illustrated by an apparatus which will give some of the varied tones of a String Organ.)

Fourth Meeting—Monday, February 1st, 1875:

Paper by Charles E. Stephens, Esq., 'On the Fallacies of Dr. Day's Theory of Harmony; with a Brief Outline of the Elements of a New System.'

Fifth Meeting—Monday, March 1st, 1875

Paper by JOHN HULLAH, Esq., Vice-President, 'On Musical Nomenclature'

Sixth Meeting—Monday, April 5th, 1875

Paper by Dr. JOHN STAINER, M A., Mus Doc., Oxon, 'On the Principles of Musical Notation.'

Seventh Meeting—Monday, May 3rd, 1875

Paper by R. H. M. BOSANQUET, Esq., M A, F.R A S, F.C S, Fellow of St John's College, Oxon, 'On Temperament; or, The Division of the Octave.' (Second Part) Illustrated—

1. Points of historical interest. 2. Formation of Scales and properties of Systems. 3. Instrumental means of control.

Eighth Meeting—Monday, June 7th, 1875

Paper by ALEXANDER JOHN ELLIS, Esq, F R S, 'Illustrations of Just and Tempered Intonation.'

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The Authors of the respective Papers are alone responsible for the opinions expressed in them, as well as for the correctness of the illustrations.

GEORGE ALEXANDER MACFARREN, Esq.,
Vice-President, in the Chair.

ON EXTENDING THE COMPASS AND INCREASING THE TONE OF STRINGED INSTRUMENTS, WITH ESPECIAL REFERENCE TO THE AUTHOR'S AND MR. MEESON'S ELLIPTICAL TENSION-BARS.

By Dr. W. H. Stone, M.A., F.R.C.P.

The author, in commencing, congratulated the society, and especially Mr. W. Spottiswoode, its earliest promoter, on its successful establishment, and on the brilliant names included in the list of original members. He expressed a decided opinion that music as an art had been too much divided from music as a science, and especially from acoustics, its natural basis. Acoustics was not even, as far as he was aware, taught in musical academies, where instruction was commenced from the other side of the shield. The tendency to exclusiveness on the part of professional musicians had, perhaps, some connection with this neglect of the study of the scientific branch of the subject. Music, though one of the greatest enjoyments granted to man, is not a necessity, like food, and the rule of political economy that supply creates demand is peculiarly applicable to it. He believed it to be to the truest interest of all professional musicians to encourage amateurs, for it should not be forgotten that they formed an intelligent audience, competent to distinguish real from false art. In return, the scientific amateur could give much to the artist, as might be seen from the works of Sir G. B. Airy (the Astronomer Royal), of Mr. Sedley Taylor, and Professor Donkin. The author gave several instances in which, as he considered, professional musicians might gain from their amateur brethren, and as a case in point he alluded to the recent attempts to introduce the French pitch at the London opera-houses. Certainly the bands had

played out of tune, but they had not played to French pitch, and he had no hesitation in saying that the pitch of the orchestra was at least a quarter of a note above the French diapason. If they had begun to tune from the bottom upwards, instead of from the top downwards, they would not have had to endure the cacophony which had made the performances of the season so painful. Turning to the special subject of his paper, the author said that he had been, as some of his audience might be aware, endeavouring for several years to extend the compass of orchestral instruments downwards. In the wind department he thought he might say that he had succeeded, by introducing an old instrument, the contra-fagotto, remodelled, and he hoped improved. He had found the same want in the string department. He had exhibited a double bass, strung down to the same pitch, CCC on the organ, in the Exhibition of 1872. The note was frequently used by Beethoven, Onslow, and other great writers, while Gounod used even the B flat below. The author said his object had been to obtain the low notes of the 16-foot octave without increasing the size of the instrument. There were three ways in which a string might be made to give these slow vibrations: first, by increased length; secondly, by increased thickness; thirdly, by increased weight—the last of which had been too much overlooked. The result of the first plan of increased length can be seen in the monster double-bass of the late Duke of Leinster at South Kensington, which would require a giant to play it. The first plan, then, did not answer. He next tried increase of thickness, but found that this also failed, owing to its aptness to produce squeaks, in consequence of transverse vibration. The other means was to increase the specific gravity of the string. It was this third plan which he had adopted. The gut string was covered with heavy copper-wire, like the bass strings of a pianoforte; and this proved to be fairly successful, though probably gold or platinum would answer still better. The double-bass shown at South Kensington was rather lacking in tone, as more resonance was wanting to bring it out fully, and this had led to his consulting Mr. Meeson as to the possibility of reinforcing the vibrations by means of longitudinal struts or bars. It was evident the belly of the instrument required to be made more homogeneous to vibration, and stiffer without increasing its weight or bulk. Mr. Meeson had carried out this idea most ingeniously. Four strips of white deal, curved to an elliptical figure, pass parallel, from end to end, on the inside of the belly. Thus they intercept the S-shaped sound-holes and remove a well-known cause of weakness and a break in the vibrating body. The result is the removal of what the musicians term 'wolf,' or inequality and falseness of tone, with a great increase of power throughout the instrument. It had since appeared that the same process is equally applicable to the smaller members of the violin family, and the author asserted that by its adoption a common instrument can be made nearly equal in tone to an old Italian

fiddle, while it strengthens the tone of old instruments in which, from decay or other causes, the power is small. The application of the process in no way damages an instrument, and the bars can be removed at pleasure. As an example of what might be effected by the system he advocated, Dr. Stone introduced to the society a young violinist, who played upon an instrument to which his process had been applied, and the original cost of which was 1s. 9d. Other instruments were shown and tried, which were of considerable age and value. By way of illustration of the practical results of thus extending the compass of the instruments of the string band, a quintet by Onslow was played, which was written by the composer down to CCC (the note now reached by Dr. Stone's method), and which could not have been played as written on the instruments in ordinary use.

The CHAIRMAN remarked that the making of violins had always possessed somewhat of a mysterious character, and men of the present generation had wondered at the prodigious superiority of the work of old makers. He eulogised the invention now brought forward, which he thought likely to prove of much value.

TEMPERAMENT; OR, THE DIVISION OF THE OCTAVE.

By R. H. M. BOSANQUET, M.A., F.R.A.S., F.C.S., Fellow of St. John's College, Oxford.

PART I.

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1. INTRODUCTION.

THE investigations which form the subject of the present communication had their origin in a practical source. It is conceived important that this should be understood, as many musicians regard the problem as a purely theoretical one, undeserving of practical attention. It was in taking part in the tuning of an organ that the effect of the ordinary equal temperament was first realised by the writer as a matter affecting musical sounds in practice, as distinguished from theory. It is the writer's experience that after the ear has once been attracted to this effect, it never fails to perceive it in the tones of instruments tuned in the ordinary way. Some tones show the effect more, some show it less. Among keyed instruments the worst effects are produced by the ordinary harmonium; next to this comes the full-toned modern grand piano, which is often unpleasant in slow harmony, especially if, as is generally the case, the temperament is not very uniform,* and the best tones, which show

* The chord of E major is constantly found 'rank' on these pianos. This would suggest some defect in the process of tuning ordinarily used.

the effect least, are those of soft-toned pianos with little power, and the ordinary organ diapason-stops—especially those old-fashioned, sweet-toned diapasons, which are rapidly disappearing before the organ-builders of the present day. The constant perception of these effects served as an inducement to a study of the subject, pursued in the first instance with the practical object of the improvement of instruments, and afterwards also for the sake of the interest attaching to the theory developed.

The problem to be dealt with is well stated as follows, in the Preface to 'A Theory of Harmony, founded on the Tempered Scale,' by Dr. Stainer:—'When musical mathematicians shall have agreed amongst themselves upon the exact number of divisions necessary in the octave; when mechanists shall have constructed instruments upon which the new scale can be played; when practical musicians shall have framed a new notation, which shall point out to the performer the ratio of the note he is to sound to the generator; when genius shall have used all this new material to the glory of art—then it will be time enough to found a new theory of harmony on a mathematical basis.'

This passage was of considerable use in directing attention to the points of importance in theory; it contains, however, some confusion of ideas, as will be pointed out immediately.

In the first place, before any conclusion can be come to as to the number of divisions necessary in the octave, it is clear that the theory of the division of the octave must be studied in a more complete and comprehensive manner than has been usual in the theory of music. In fact, when we come to examine the subject, we shall find that, although the properties of isolated systems have been studied here and there, yet no comprehensive method has been given for the derivation and treatment of such systems,* and the establishment of such a method will be the first point which will demand our attention. We shall then come to the conclusion that different systems have their different advantages; and we may contemplate the possibility of music being written for, or adapted to, one system or another, just as hitherto music has been written for performance in one key or another of the equal temperament.

In the second place, notation will be provided, by which the exact note intended to be played can be indicated to the performer, in those systems in which a modification of the ordinary notation is necessary. The notation is so constructed as to supplement the ordinary notation without altering it, and the signs required in addition to the ordinary notation are few in number and simple in their character.

Again, the problem of instruments has been solved in a general manner as far as keyed instruments are concerned. A generalised keyboard has been devised, by means of which it is

* See however, Mr. A. J. Ellis on the 'Temperament of Musical Instruments with Fixed Tones'—Royal Society's Proceedings, 1864.

possible to control the notes of all systems which proceed by continuous series of equal fifths; and this keyboard has been constructed and applied.

The confusion of ideas above alluded to arises from the assumption that the theory to be employed will be based on the derivation of scales from some one harmonic series, as well as from the division of the octave. Now this will never be true. If scales are derived from the division of the octave, their notes can never be more than approximations to the notes of any one harmonic series. In some of the systems subsequently developed, conditions having reference to the properties of harmonics will be employed; for example, we may make our fifths or our thirds perfect. This class of conditions is regarded as being derived from the harmonic series of each pair of notes employed. But the notation employed has not in any case reference to the ratio of the note sounded to any generator.

In the present introductory paper, the principal properties of the class of systems dealt with will be established in a general manner, the notation above referred to will be explained, and a brief account will be given of what may be called the 'principle of symmetrical arrangement.' This principle is the foundation of the arrangement of the keyboard above referred to, and its chief characteristic is, that any given interval, or combination of intervals, presents the same form on such an arrangement, on whatever notes it is taken—whence the form of fingering on the keyboard is the same in all keys.

2. Expression of Intervals.

Before commencing the treatment of these subjects, it will, however, be necessary to make some remarks on the method employed for the expression and calculation of intervals.

All intervals will be expressed in terms of equal temperament semitones. The letters E. T. will be used as an abbreviation for the words 'equal temperament.' Thus an octave, which is 12 E. T. semitones, will be written as 12; the 53rd part of an octave will be written as $\frac{12}{53}$, or ·22642. Five places of decimals will be generally considered sufficient.

The following rules for transforming vibrations ratios into the equivalent E. T. interval can be made use of by any one who knows how to look out a logarithm in a table. They obviously depend on the form of log. 2.—

Rule I.—To find the equivalent of a given vibrations ratio in E. T. semitones. Take the common logarithm of the given ratio, subtract $\frac{1}{300}$, and call this the first improved value (F. I. V.). From the original logarithm subtract $\frac{1}{75}$ of the first improved value, and $\frac{1}{10000}$ of the first improved value. Multiply the remainder by 40. The result is the interval, expressed in E. T. semitones.

EXAMPLE 1.—To find the values of a perfect fifth, the vibrations ratio of which is $\frac{3}{2}$ in E. T. semitones:—

Log. 3 =	·4771213	·1760913
Log. 2 =	·3010300	5850
Log. $\frac{3}{2}$ =	·1760913	·1755063
$\frac{1}{300}$ =	·0005870	175
F. I. V. =	·1755043	·1754888
		40
		7·01955|2

Thus a perfect fifth exceeds 7 semitones by ·01955.

N.B.—The rule only gives five places correct.

The true value of the perfect fifth calculated by an exact process to 20 places is:—

7·01955 00086 53874 17740

EXAMPLE 2.—To find the value of a perfect third, the vibrations ratio of which is $\frac{5}{4}$, in E. T. semitones:—

Log. 5 =	·6989700	·0969100
Log. 4 =	·6020600	3219
Log. $\frac{5}{4}$ =	·0969100	·0965881
$\frac{1}{300}$ =	·0003230	96
	·0965870	·0965785
		40
		3·86314|0 = 4 − ·13686

Thus a perfect third exceeds 3 semitones by ·86314; or, as it is generally more convenient to state the result, it falls short of 4 semitones by ·13686.

The value to 20 places is:—

4 − ·13686 28813 81651 82581

RULE II.—To find the vibrations ratio of an interval given in E. T. semitones.

To the given number add $\frac{1}{300}$ and $\frac{1}{10000}$ of itself. Divide by 40. The result is the logarithm of the ratio required.

EXAMPLE.—The E. T. third is 4 semitones. The vibrations ratio, found as above, is 1·25992. Hence the vibrations ratio of the E. T. third to the perfect third is nearly 126 : 125.

3. DEFINITIONS.

Regular Systems are such that all their notes can be arranged in a continuous series of equal fifths.

Regular Cyclical Systems are not only regular, but return into the same pitch after a certain number of fifths; every such system divides the octave into a certain number of equal intervals.

Error is deviation from a perfect interval.

Departure is deviation from an E. T. interval.

Intervals taken upwards are called positive, taken downwards negative.

Fifths are called positive if they have positive departures, that is, if they are greater than E. T. fifths; they are called negative if they have negative departure, that is, if they are less than E. T. fifths. We saw that perfect fifths are more than 7 semitones; they are therefore positive.

Systems are said to be positive or negative according as their fifths are positive or negative.

Regular Cyclical Systems are said to be of the rth order, positive or negative, when the departure of 12 fifths is $\pm\, r$ units of the system.

Thus, we shall see later that in the system of 53 the departure of 12 fifths is 1 unit upwards, and the system is positive of the first order; in the system of 118 the departure of 12 fifths is 2 units upwards, and the system is said to be positive of the second order. In the system of 31 the departure of 12 fifths is one unit downwards, and the system is negative of the first order; and in the system of 50 the departure of 12 fifths is two units downwards, and the system is negative of the second order. Systems of the first order are called Primary, of the second order Secondary.

4. Formation of Intervals by Series of Fifths.

When successions of fifths are spoken of, it is intended that octaves be disregarded. If the result of a number of fifths is expressed in E. T. semitones, any multiples of 12 (octaves) may be subtracted or added.

As an example, we will consider some of the intervals formed by successive fifths in the system of 53. We shall see later (Theorem iv.) that the fifth of this system is $7\frac{1}{53}$, i.e., it exceeds the equal temperament fifth by $\frac{1}{53}$ of an E. T. semitone. This being premised, we have the following intervals, amongst others.—

Departure of 12 fifths $= \frac{12}{53}$.

For $12 \times 7\frac{1}{53} = 84\frac{12}{53}$; and we subtract 84, which represents 7 octaves.

Two-fifths tone $= 2\frac{2}{53}$.

For $2 \times 7\frac{1}{53} = 14\frac{2}{53}$; and we subtract 12, which represents 1 octave.

* Seven-fifths semitone, formed by 7 fifths up, $= 1\frac{7}{53}$.

For $7 \times 7\frac{1}{53} = 49\frac{7}{53}$; and we subtract 48, which represents 4 octaves.

* Five-fifths semitone, formed by 5 fifths down, $= 1 - \frac{5}{53}$.

For $5 \times -7\frac{1}{53} = -35\frac{5}{53}$; and we add 36, which represents 3 octaves.

* These expressions were suggested to the writer by Mr. Parratt.

Or, if we consider the system of 31 in which the fifth is
$7 - \frac{1}{31}$, we have, similarly.

Departure of 12 fifths	$= \quad - \frac{12}{31}$
Two-fifths tone	$= 2 - \frac{2}{31}$
Seven-fifths semitone	$= 1 - \frac{7}{31}$
Five-fifths semitone	$= 1\frac{5}{31}$

5. Regular Systems.

The importance of Regular Systems arises from the symmetry of the scales which they form.

Theorem i.—In any regular system 5 seven-fifths semitones and 7 five-fifths semitones make up an exact octave.

For the departures from E. T. of the 5 seven-fifths semitones are due to 35 fifths up, and the departures of the 7 five-fifths semitones are due to 35 fifths down, leaving 12 E. T. semitones, which form an exact octave.

Example.—A perfect fifth $= 7 + \delta$, where $\delta = .01955$.
Then the seven fifths semitone is $1 + 7\delta$,
the five-fifths semitone is $1 - 5\delta$,
and 5 seven-fifths semitones, together with 7 five fifths semitones, is,—
$$5(1 + 7\delta) + 7(1 - 5\delta) = 5 + 35\delta + 7 - 35\delta = 12$$

Theorem ii.—In any regular system the difference between the seven-fifths semitone and the five-fifths semitone is the departure of 12 fifths, having regard to sign.

That is to say, if we subtract the five-fifths semitone from the seven-fifths semitone, the result is equal to the departure of 12 fifths in value; and it is positive if the fifths are positive, and negative if the fifths are negative.

For the seven-fifths semitone up is one E. T. semitone up and the departure of 7 fifths up, and the five-fifths semitone down is one E. T. semitone down and the departure of 5 more fifths up—which makes, on the whole, the departure of 12 fifths up; and if the single departures are positive, then the twelve departures are positive, and if negative, negative.

Example 1.—A perfect fifth $= 7 + \delta$ as before, and δ is positive.
And seven-fifths semitone $= 1 + 7\delta$
five-fifths semitone $= 1 - 5\delta$,
whence, subtracting the lower line, the difference $= 12\delta$.

Example 2.—A fifth of the system of 31 $= 7 - \frac{1}{31}$, and it is negative.
The seven-fifths semitone $= 1 - \frac{7}{31}$
Five-fifths semitone $= 1 + \frac{5}{31}$
whence, subtracting the lower line, the difference $= -\frac{12}{31}$.

6. Regular Cyclical Systems.

The importance of Regular Cyclical Systems arises from the infinite freedom of modulation in every direction which is

possible in such systems when properly arranged, whereas in non-cyclical systems required modulations are liable to be impossible, owing to the demand arising for notes outside the material provided.

Theorem iii.—In a Regular Cyclical System of order $\pm r$, the difference between the seven-fifths semitone and five-fifths semitone is $\pm r$ units of the system.

For, recalling the definition of rth order (departure of 12 fifths $= \pm r$ units), the proposition follows from Theorem ii.

EXAMPLE 1.—In the system of 53 the fifth is $7\frac{1}{53}$;

$$\text{Seven-fifths semitone} = 1\tfrac{7}{53}$$
$$\text{Five fifths semitone} = 1 - \tfrac{5}{53},$$

whence subtracting, the difference is $\frac{12}{53}$, which is the octave divided by 53, or one unit of the system.

EXAMPLE 2.—In the system of 31 the fifth is $7 - \frac{1}{31}$, and, as before, the difference is $-\frac{12}{31}$, or − (one unit of the system)

Corollary.—This proposition, taken with Theorem i., enables us to determine the numbers of divisions in the octave in systems of any order, by introducing the consideration that each semitone must consist of an integral number of units. The principal known systems are here enumerated :—

7-fifths semitone $= x$ units	5-fifths semitone $= y$ units	Number of Units in octave (Th. i.) $5x + 7y = n$
	Primary (1st order) Positive	
2	1	17
3	2	29
4	3	41
5	4	53
6	5	65
	Secondary (2nd order) Positive.	
11	9	118
	Primary Negative.	
1	2	19
2	3	31
	Secondary Negative.	
3	5	50

The mode of formation in other cases is obvious.

Passing over, for the present, the derivation of scales from this scheme, we proceed to other important theorems on Cyclical Systems :—

Theorem iv.—In any Regular Cyclical System, if the octave be divided into n equal intervals, and r be the order of the system, the departure of each fifth of the system is $\frac{r}{n}$ E. T. semitones.

Let the departure of each fifth of the system be δ. Then the departure of twelve fifths $= 12\,\delta = r$ units by definition, and

the unit $=\frac{12}{n}$ E. T. semitones (since the octave, which is 12 semitones, is divided into n equal parts). Hence

$$12\,\delta = r\,\frac{12}{n} \text{ or } \delta = \frac{r}{n}$$

EXAMPLE 1.—In the system of 53, which is of the first order and positive (Th. iii. Cor.), the departure of 12 fifths = 1 unit, $=\frac{12}{53}$, whence the departure of one fifth $=\frac{1}{53}$.

EXAMPLE 2.—In the system of 118, which is of the second order and positive, the departure of 12 fifths is 2 units, $=2.\frac{12}{118}$, whence the departure of one fifth is $\frac{2}{118}$, or $\frac{1}{59}$.

EXAMPLE 3.—In the system of 31, which is of the first order and negative, the departure of each fifth is $-\frac{1}{31}$.

EXAMPLE 4.—In the system of 50, which is of the second order and negative, the departure of each fifth is $-\frac{1}{25}$.

Theorem v.—If, in a system of the rth order, the octave be divided into n equal intervals, $r+7n$ is a multiple of 12, and $\frac{r+7n}{12}$ is the number of units in the fifth of the system.

Let ϕ be the number of units in the fifth.

Then $\phi\,.\,\frac{12}{n}$ is the fifth, and $=7+\delta$, if δ be the departure of the fifth; $=7+\frac{r}{n}$ by Th. iv.

Hence $\phi=\frac{7n+r}{12}$,

and ϕ is an integer by hypothesis—whence the proposition.

From this proposition we can deduce corresponding values of n and r. This is useful in investigating systems of the higher orders. Casting out multiples of 12, where necessary, from n and r, we have the following relations between the remainders:—

Remainder of

n	1	2	3	4	5	6	7	8	9	10	11
r	5	10	3	8	1	6	11	4	9	2	7
	−7	−2	−9	−4	−11	−6	−1	−8	−3	−10	−5

EXAMPLE.—It is required to find the order of the system in which the octave is divided into 301 equal intervals.

300 is a multiple of 12, remainder 1 gives order 5, or − 7. 301 is a system of some interest regarded as a positive system of order 5, in consequence of its having, as we shall see later, tolerably good fifths and thirds, while its intervals are expressed by the first three places of the logarithms of the vibration ratios, 3010 being the first four places of log 2. Mr. Ellis has recently made use of this system.—(Royal Society's Proceedings, 1874.)

Theorem vi.—If a system divide the octave into n equal intervals, the total departure of all the n fifths of the system $=r$ E. T. semitones, where r is the order of the system.

For, if δ be the departure of one fifth, then, by Th. iv.,

$$\delta = \frac{r}{n}; \text{ whence } n\,\delta = r.$$

or the departure of n fifths $= r$ semitones.

EXAMPLE 1.—The departure of 53 fifths of the system of 53 is 1 semitone; for the departure of one fifth is $\frac{1}{53}$ by Th. iv.

EXAMPLE 2.—The departure of 118 fifths of the system of 118 is 2 semitones, for the departure of one fifth is $\frac{2}{118}$.

EXAMPLE 3.—The departure of 31 fifths of the system of 31 is -1 semitone (one semitone flat), for the departure of one fifth is $-\frac{1}{31}$.

EXAMPLE 4.—The departure of 50 fifths of the system of 50 is -2 semitones.

This theorem gives rise to a curious mode of deriving the different systems.

Suppose the notes of an E. T. series arranged, on a horizontal line, in the order of a succession of fifths, and proceeding onwards indefinitely, thus:

c g d a e b f♯ c♯ g♯ d♯ a♯ f c g . . . .

and so on.

Let a regular system of fifths start from *c*. If they are positive, then at each step the pitch rises farther from E. T. It can only return to *c* by sharpening an E. T. note.

Suppose that *b* is sharpened one E. T. semitone, so as to become *c*, then the return may be effected—

at the first *b* in 5 fifths
—— second *b* in 17 fifths
—— third *b* in 29 fifths,—

and so on. Thus we obtain the primary positive systems.

Secondary positive systems may be got by sharpening *b♭* by two semitones, and so on. If the fifths are negative, the return may be effected by depressing *c♯* a semitone in 7, 19, 31, . . fifths; we thus obtain the primary negative systems, or by depressing *d* two semitones, by which we get the secondary negative systems,—and so on.

FORMATION OF MAJOR THIRDS.

7. NEGATIVE SYSTEMS.

The departure of the perfect third is $-.13686$, as we have seen (section 2), that is to say, it falls short of the E. T. third by this fraction of an E. T. semitone. Hence negative systems, where the fifth is of the form $7-\delta$, form their thirds in accordance with the ordinary notation of music. For if, in such a system, we form a third by taking four fifths up, we have a third with negative departure $(=-4\delta)$, which can approximately represent the departure of the perfect third. Thus, *c♯* is either the third to *A*, or four fifths up from *A*, in accordance with the usage of musicians.

EXAMPLE.—In the system of 31 the departure of each fifth is $-\frac{1}{31}$, and that of the third by four fifths up is $-\frac{4}{31} = -\cdot12903$, and this differs from the departure of the perfect third ($= -\cdot13686$) only by the small error $\cdot00783$, or considerably less than the hundredth of a semitone.

8. POSITIVE SYSTEMS.

Positive systems, on the other hand, form their approximately perfect thirds by 8 fifths down; for their fifths, being larger than E. T. fifths, depress the pitch below E. T. when tuned downwards. Thus, if the fifth be of the form $7+\delta$, 8 fifths down give the negative departure ($=-8\delta$), which can approximately represent the departure of the perfect third. Thus the third of A should be D♭, which is inconsistent with musical usage. Hence positive systems require a separate notation, to which we will return immediately.

EXAMPLE 1.—Regular system of perfect fifths. The departure of a perfect fifth is $\cdot01955$, as we have seen. Eight fifths down give therefore a departure $= -8 \times \cdot01955 = -\cdot15640$, and this exceeds the departure of a perfect third ($= -\cdot13686$) by the error $\cdot01954$, a quantity which is the same, within one unit in the last place, as the departure of the perfect fifth, or the error of the E. T. fifth, which is the same thing.

EXAMPLE 2.—System of 53. Departure of third by 8 fifths down $= -\frac{8}{53} = -\cdot15094$.

EXAMPLE 3.—System of 118. Departure of third by 8 fifths down $= -\frac{8}{59} = -\cdot13560$, the error of which is little more than the thousandth part of a semitone.

9. NOTATION.

Helmholtz employs a peculiar notation for the system generally called by his name, which has very nearly perfect fifths and perfect thirds.* We shall speak of this system in general as the positive system of perfect thirds. Helmholtz's employment of this notation is marked by several peculiarities, which we need not here discuss; the objection that this notation is unsuitable for use with musical symbols is sufficient to warrant us in disregarding it.

The following notation is here adopted for positive systems in general: it is not intended to be limited to any one system, like Helmholtz's. In fact, as it consists entirely of an indication of position in a series of fifths, it may, when desired, be used with negative systems.

The notes are arranged in series, in order of successive fifths. Each series contains twelve fifths, from *f*♯ up to *b*. The series *f*♯—*b* is called the unmarked series; it contains the standard, or unmarked *c*. Each note of the next series of twelve fifths up is affected with the mark (/), which is called a mark of elevation,

* See note at p. 121, *post*.

and is drawn upwards in the direction of writing The next series of twelve fifths up is affected with the mark (//); and the succeeding series of twelve fifths up are affected with a number of marks of elevation corresponding to their position, (///),(////), and so on The series below the unmarked series is affected with the mark (\\), which is called a mark of depression, and is drawn downwards in the direction of writing, and the succeeding series, in a descending order of fifths, are affected with a number of marks of depression corresponding to their position, (\\\\), (\\\\\\), and so on. Such fifths as *\\b–f♯*, *b–/f♯*, which join any two of the series of the notation, have the same value as all the rest.

Thus, for example, the interval *c–/c* is the departure of twelve fifths. *c–\\e* are related through eight fifths downward from *c* Hence in positive systems *\\e* is the note which forms an approximately perfect third with *c*

N B —It is to be noted that the position in the series of fifths is determined only by the notation here introduced; *i e*, *c♯* and *d♭* mean exactly the same thing, and refer only to one of the twelve E T. divisions of the octave Regarded as belonging to an assigned system, *c♯* or *d♭* would mean that note of the unmarked series which is five fifths below the unmarked or standard *c*

10. Rule for Thirds in Positive Systems.

If we write down one of the series of the notation:—

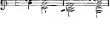
f♯–c♯–g♯–d♯–a♯–f–c–g–d–a–e–b,

and remember that positive systems form their thirds by eight fifths down, we have the rule:—

The four accidentals on the left in any series of the notation form major thirds to the four notes on the right of the same series All other notes have their major thirds in the next series below. Thus, *d–f♯* and *c–\\e* are major thirds

11. Employment of the Notation in Music

This notation is suitable for employment with written music. Its appearance will be generally taken to indicate the employment of a system with perfect or approximately perfect fifths, unless anything is said to the contrary

The following passage is an example:—

The interval *g–f* is a close approximation to the harmonic or natural seventh; */a♭–f♯* is rendered very smooth by the employment of the same interval. The development of the practical use of the notation is deferred for the present.

The notation is also useful for the discussion of some systems of historical interest. Thus, we have a scale of F in Mersenne, whose work bears the date 1636, with eighteen notes to the octave. This possessed the following resources:—

Major chords of *c–f–b♭–e♭*,
 „ *\e–\a–\d–\g*, thirds to the above.
 „ */a♭–/d♭–/g♭*, thirds below *c–f–b♭*.

Minor chords of *c–f–b♭–e♭*,
 „ *\e–\a–\d–\g*, thirds to the above.
 „ *\c♯–\f♯–\\b*, thirds to *\a–\d–\g*.

We have here the two forms of second of the key, *g* and *\g*, differing approximately by a comma. This double form appears in all good attempts at systems with perfect fifths.

12. The 'Generalised Keyboard.'

A keyboard has been designed and constructed, by means of which the notes of all regular systems, positive and negative, can be brought under the control of the fingers. The detailed account of this keyboard is deferred for the present. It contains eighty-four keys in every octave; the instrument of which it forms a part is a harmonium, and the system of tuning is that which divides the octave into fifty-three equal intervals. The form of fingering is the same in all keys. Such passages as the example in musical type given above can be readily performed upon it.

SYMMETRICAL ARRANGEMENT OF THE NOTES OF THOMPSON'S ENHARMONIC ORGAN.

The Subscripts 1, 2, and 3 refer to its Three Keyboards

12	$'c_1$	.	.	.	.	.	.	.	.	.	.	.	$'c_1$
11	.	.	.	.	.	$'f_1$	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	$'b\flat_1$	.	.
9	.	.	.	$'e\flat_1$	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	$'a\flat_1$	.	.	.	.
7	.	$'c\sharp_1$	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	$'f\sharp_1$	.	.	.	.	.	.
5													
4	.	.	.	.	e_1	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	$a_{1\cdot 2}$	.	.	.
2	.	.	$d_{1\cdot 2}$	.	.	.	.	.	.	.	.	.	.
1	.	.	.	.	.	.	.	$g_{1\cdot 2\cdot 3}$	.	.	.	.	.
12	$c_{1\cdot 2\cdot 3}$	.	.	.	.	.	.	.	.	.	.	.	$c_{1\cdot 2\cdot 3}$
11	.	.	.	.	.	$f_{1\cdot 2\cdot 3}$	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	$b\flat_{1\cdot 2}$	.	.
9	.	.	.	$e\flat_{1\cdot 2}$	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	$a\flat_2$	.	.	.	.
7	.	$c\sharp_2$	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	$f\sharp_{1\cdot 2}$	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	$'b_{1\cdot 2\cdot 3}$	.
4	.	.	.	.	$'e_{1\cdot 2\cdot 3}$	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	$'a_{1\cdot 2\cdot 3}$	.	.	.
2	.	.	$'d_{1\cdot 2\cdot 3}$	.	.	.	.	.	.	.	.	.	.
1	.	.	.	.	.	.	.	$'g_{1\cdot 2\cdot 3}$	.	.	.	.	.
12	$'c_2$	.	.	.	.	.	.	.	.	.	.	.	$'c_2$
11	.	.	.	.	.	$'f_2$	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	$'b\flat_2$	.	.
9	.	.	.	$'e\flat_2$	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	$'a\flat_{2\cdot 3}$	.	.	.	.
7	.	$'c\sharp_{2\cdot 3}$	.	.	.	.	.	.	.	.	.	.	.
6	.	.	.	.	.	.	$'f\sharp_{2\cdot 3}$	.	.	.	.	.	.
5	.	.	.	.	.	.	.	.	.	.	.	$''b_{2\cdot 3}$	.
4	.	.	.	.	$''e_3$	.	.	.	.	.	.	.	.
3	.	.	.	.	.	.	.	.	.	$''a_3$	.	.	.
2													
1	.	.	.	.	.	.	.	$''g_3$	.	.	.	.	.
12	$''c_3$	.	.	.	.	.	.	.	.	.	.	.	$''c_3$
11	.	.	.	.	.	$''f_3$	.	.	.	.	.	.	.
10	.	.	.	.	.	.	.	.	.	.	$''b\flat_3$	.	.
9	.	.	.	$''e\flat_3$	.	.	.	.	.	.	.	.	.
8	.	.	.	.	.	.	.	.	$''a\flat_3$	.	.	.	.
7	.	$''c\sharp_3$	.	.	.	.	.	.	.	.	.	.	.

13. Principle of Symmetrical Arrangement.

This principle is employed in the design of the above-mentioned keyboard; and it is owing to its properties that the fingering is the same in all keys. It may be thus stated:—

If we place the E. T. notes on a horizontal line in the order of the scale, and set off the departures of the notes of any system at right angles to the E. T. line, sharp departures up and flat departures down, we obtain the positions of a symmetrical arrangement. The accompanying table is a symmetrical arrangement of the notes of General Thompson's enharmonic organ. The following series of intervals lie on characteristically-placed straight lines in a symmetrical arrangement.—

Name of interval in general case	Name when fifths are perfect.	Sense of intervals
2-fifths tone	Major tone	*c–d–e* .
5-fifths semitone . . .	Pythagorean semitone. .	/*c*–/*c*♯–*d*–*e*♭–*e* . .
7-fifths semitone . . .	Apotomè Pythagorica . .	*c*–*c*♯–*d*–/*e*♭ . . .
Third by 4 fifths up .	Dissonant, or Pythagorean third	*c*–*e*–/*a*♭–/*c* . .
Third by 8 fifths down .	(Approximately perfect third.)	*c*–*e*–*a*♭–*c* . .

The departure of twelve perfect fifths, or the Pythagorean comma, $= 12 \times \cdot 01955 = \cdot 23460$. The ordinary comma of $(\frac{81}{80})$ is ·21506. For a certain degree of approximation we can neglect the difference between these quantities, and speak of a comma without specialising our meaning. In this sense we may read the last of the above series of intervals as showing us that three perfect thirds fall short of the octave by two commas approximately. We may return to this point hereafter.

In the symmetrical arrangement of the notes of General Thompson's organ, we may note specially, first, the effect of the distribution of the notes over these keyboards. For instance, the notes of the chord of A minor are all present ($a_{1\cdot 2}$–/c_1–$e_{2\cdot}$); but the third and fifth are on different keyboards, so that the chord would not be generally available.

Again, the notes *b* and *d* are missing from the otherwise complete scheme; we notice the number of chords which their absence destroys.

In the present paper the endeavour has been made to present to the members of the Musical Association the more fundamental portions of the theory of the subject. It is hoped that this treatment may facilitate the comprehension of such historical points and such further developments as may be hereafter brought before the Association.

Dec. 7, 1874.

The Rev. THOMAS HELMORE, M.A., in the Chair.

ON A SUGGESTED SIMPLIFICATION OF THE ESTABLISHED PITCH-NOTATION.

By Sedley Taylor, Esq., M.A., late Fellow of Trinity College, Cambridge.

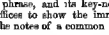
By way of introduction to the more distinctly practical portion of this paper, I propose to examine concisely the following question:—'What are the essential requisites of a good notation for musical pitch?' I shall then enquire how far the system in common use satisfies the conditions which an answer to this question must embody. Before submitting to the Association some suggestions of my own for remedying the defects which will thus be brought to light, I shall make a few observations on the leading methods by which others have sought to attain the same object. This will be done with no desire to disparage the merits of these schemes, but merely in order to show that their success has not been so complete as to render further efforts superfluous and uncalled for.

Music has, of course, an existence absolutely independent of, and prior to, all notation whatever. *Volkslieder* are handed down from generation to generation by oral tradition alone. If our language contains no recognised equivalent for the German word just used, our country none the less possesses the thing, and a distinguished member of our Association has earned the gratitude of every patriotic English musician by endowing us with a permanent record of these homely and home-recalling strains. Now what is the feature in the notes of one of these simple airs which enables us instantly to recognise it, whether we hear it whistled by a shepherd o'er the lea, or ground on a barrel-organ in a foreign land? Most certainly it is not what we call the *absolute pitch* of the different sounds heard. Whether these be the deep tones of a manly bass, or the ringing notes of a childish treble, the recognition is equally unhesitating. In fact, we no more think of calling for a 'Standard A' tuning-fork to settle the point, than we do of asking for a foot-rule to enable us to recognise the portrait of an absent friend. That the tune begins on *c*, or *g*, or *g*♯, as little influences our power of recognition in the one case, as the fact of our friend's face in the picture being 10, 11, or 12 inches long does in the other. It is, then, the *relations* of pitch among the notes of a melody which fix its character, just as it is the relations of size and form among the parts of a portrait which constitute its likeness to the person whom it represents. Of

course I am here designedly leaving the other elements of melody—time and rhythm—out of consideration, as they do not affect our present enquiry.

From what has been said above, an important conclusion immediately follows In representing the constituent notes of a melody by a series of symbols, full effect must be given to the consideration that the mutual relations of these notes to each other are of paramount importance, while their relations to some fixed standard of pitch extraneous to the melody are of very secondary consequence In other words, a direct exhibition of *intervals* is the first requisite of a good notation By all means provide equally well for absolute pitch, if possible, but not by subordinating relative pitch to it. If there is not room on the stairs for the two to go down to dinner arm-in-arm, absolute pitch must walk behind.

The point of departure from which intervals should be reckoned is implicitly determined by the tendency of modern music to establish a direct relationship between each of the notes which form a musical phrase, and its key-note or tonic. The simplest experiment suffices to show the immediateness of the connection Thus, if the notes of a common chord in its fundamental position,



are successively sounded, what at once strikes the ear is the fact that the last three notes form respectively a third, fifth, and octave *with the first* The intervals they form *with each other*, viz, minor third, fourth, and minor sixth, pass altogether unnoticed, and in order to determine them our attention must be specially directed to the enquiry. In short, relation to the *key-note* is instinctively recognised by the ear as *direct*: relation to any other note possesses no such prerogative. It follows that the intervals exhibited by a good notation of pitch must be *tonic* intervals—*i e*, they are to be reckoned from the key-note

Assuming, then, that tonic intervals are to be represented, the question arises, what the precise *extent* of these intervals is to be? The answer which at once suggests itself is that the intervals must be those which are pronounced by the ear to be *perfectly in tune*, but this consideration, though pointing to the true and only final authority in the case, is not of itself immediately decisive of the question To obtain a perfectly definite answer recourse must be had to acoustical science, which will decide the point as follows. The only intervals which strike the ear as perfectly in tune are those which accurately satisfy certain simple numerical relations connecting the number of vibrations executed in the same time by the pairs of notes which form such intervals

with each other. The intervals thus defined are termed *natural*, in contradistinction to all others, which are called *tempered*. The position just laid down is no mere *opinion*, but an ascertained physical *fact*, as certain as that water consists of oxygen and hydrogen in the proportion of one volume of the former to two of the latter. No person who has adequately studied the evidence on which the established conclusions of physical science rest will seriously propose to dispute the competence of acoustics on a matter unquestionably lying within its jurisdiction. At the same time, many of those whose acquaintance with music has been limited to its artistic and æsthetic side, are naturally reluctant to accept a series of dogmatic decisions imposed on the bare authority of acoustical science, and perhaps stated by some of its expositors with an irritating arrogance of tone. Now, that resolute, manly independence of mind which refuses to submit to any authority whose credentials it has not had the means of adequately verifying, is not to be put down by oracular rumblings from men of science, but must be satisfied by the production of *arguments*, whenever the nature of the subject in hand allows these to be presented in an untechnical and intelligible form. It fortunately happens that, with regard to the question of natural and tempered intervals, I can appeal to experiments which will come home to the most non-scientific or anti-scientific person present. Professor Helmholtz had a harmonium constructed, on which, starting from an assigned tonic, he was able to play either natural or tempered intervals. In order to ascertain which of the two were selected by a singer in executing a simple melody, he accompanied the opening notes on his harmonium, and then ceased playing. When the vocalist sang a third or a sixth—intervals where the defects of the system of equal temperament are the most considerable—he struck either the corresponding natural or the corresponding tempered note on the instrument. The result Helmholtz states to have been that *in every case the voice was in unison with the natural interval and in dissonance with the tempered one*.[1] A similar comparison made with the sounds of a violin derives a special interest from the name of the artist who assisted on the occasion. 'I had,' writes Helmholtz, 'the happy opportunity of instituting experiments of the same kind on my harmonium with Herr Joachim. His tuning of the strings of his violin produced *exact coincidence with the natural g, d, a, e of my instrument*. I next asked him to play the scale, and the moment he reached the third or sixth, I struck the corresponding note on the harmonium. By means of the beats it was easy to ascertain that *this distinguished musician played natural, not tempered, thirds and sixths*.'[2] Is it a mere fancy if, in this striking and conclusive experiment, which shows us the greatest physical

[1] *Tonempfindungen*, third edition, pp. 633, 634.

[2] *Ibid.* p. 506. The technical notation used by the author has compelled me to paraphrase the above extract, but its meaning has not undergone a shade of alteration.

philosopher and the most eminent artist in Europe working together side by side for the further attainment of truth, I seem to see a good augury for that happy and fruitful union between the Science of Acoustics and the Art of Music which it is the aim of this Association to foster and, as I hope, its destiny to consummate?

It would be easy to point out further objects which it is desirable that a notation should secure, and some of these will come under our notice further on. For the present we will restrict our demands to these two, that it shall indicate, in some plain and straightforward way, *tonic intervals*, and that these intervals shall be *natural*, not tempered ones. Let us see how far the established notation satisfies these requirements.

As long as we keep to the key of C, tonic intervals are clearly and directly exhibited by the established notation. They can be counted off from the starting-point indicated by the clef with all the facility to be desired. But when other keys have to be represented by it, this is no longer the case. We are then merely directed to widen or narrow some—or possibly all—of the intervals of the C scale, by certain symbols prefixed to the corresponding notes of that scale That in this manner fresh scales similar to the C scale are obtained is a fact of independent experience, which, as far as anything contained in the notation is concerned, might equally well not be true at all. An easy rule, no doubt, enables us to determine whether any (and if so what) key a particular group of accidentals indicates, but the rule is based on information which these symbols themselves do not completely convey. There is nothing on the face of the notation to tell us *where the tonic is*, and, in the absence of such an indication, no resource but still to read all intervals off from the original starting-point C. A huge and perfectly gratuitous complication is thus introduced into a very simple matter. The sounds of a melody are no longer referred to their own tonic, but to a different note which has no real claim to their allegiance. This is very much as if the Acts of existing Parliaments were couched in language implying that not Victoria but William the Conqueror now sat on the throne of England. It is ignoring the live tonic in order by an artificial phraseology to make a dead tonic appear to breathe and govern. By a process of this description the simplest relation may be made to look complicated. Suppose I take two pieces of wood, and by merely placing them side by side ascertain that one is just twice as long as the other. So far, nothing can be more simple. But, then, an adherent of the absolute-length theory comes up and insists that both sticks shall be measured and their lengths expressed in standard feet, inches, and fractions of inches. We will suppose that this is done, and that the results come out five feet one inch and three-quarters of an inch, and two feet six inches and seven-eighths of an inch, respectively. All simplicity is, by this arrangement, entirely got rid of, and the fact that one stick is

twice as long as the other—the only thing it was really essential to communicate—is buried under a heap of intrusive arithmetic, from which nothing less than a sum in compound division of vulgar fractions will suffice to unearth it.

In order to show that this illustration fairly represents the procedure embodied in the established pitch-notation, let me take an instance or two, almost at random.

What, for instance, is the direction conveyed by

 ?

'Strike a minor seventh from middle C, and then a ninth from the same note, or a whole tone from its octave.' Every singer feels at once how difficult the second step appears when thus indicated. But the difficulty is solely due to the fact that the direct relation of the second note to the first has been superseded by the indirect relations of both to a third. If the direct relation be restored, and the singer told to follow the first note by a second a major third above it, the step which before was hard now appears perfectly easy. Similarly,

,

which orders a minor third, a fifth, and a minor seventh from C to be successively sounded, is only an obscure and roundabout way of calling for a major triad on E♭ as root. Instances in which such needless difficulties are heaped up to an almost intolerable degree will abundantly occur to your recollection.

Our patient and even contented, nay complacent, submission to this heavy yoke seems to me all the more extraordinary when I remember that, in immediate juxtaposition with our complicated *absolute* pitch-notation, we have a perfectly simple *relative* time-notation, the simplicity of which is directly due to the fact that it is relative, and would disappear the moment we attempted to make it absolute. Suppose that our notation, instead of presenting us with minims twice as long as crotchets, and crotchets twice as long as quavers, were based like the pitch-notation on some fixed standard, and indicated the duration of these notes by the number of seconds or fractions of a second for which each was to be held. The opening of 'Rule Britannia' at the usual *tempo* would then be written, as far as time went, as follows:—

$$\frac{15}{34}\ \Big|\ \frac{15}{17}\,\frac{15}{17}\ \Big|\ \frac{15}{68}\,\frac{15}{88}\,\frac{15}{68}\,\frac{15}{68}\,\frac{15}{34}\,\frac{15}{34}\ \Big|\ \frac{15}{17}\,\frac{15}{34}\,\frac{15}{88}\,\frac{15}{68}\ \Big|\ \frac{45}{34}$$

The fact that our time-notation becomes hopelessly complicated when its relative basis is replaced by an absolute one, ought to encourage us to expect a great simplification from a precisely opposite change effected in our pitch-notation.

The established notation, it has been seen, only indicates tonic intervals in a single key, and this circumstance is fatal to all directness and simplicity of representation in other keys. Further, as is perfectly well known, its intervals except that of the octave are tempered, *i.e.*, out of tune. It is well adapted to the purposes of an instrument with twelve fixed tones in the octave, tuned on the system of equal temperament, but totally inadequate to supply the needs of more perfect instruments which have the happy privilege of roaming unconstrainedly over the whole range of pitch within their compass. Now, to impose on these latter a notation based on the infirmities of the former is just as if, having succeeded in constructing an automaton man, whose feet could execute exactly twelve movements, we were to decree that henceforth all dancing-masters should teach their pupils on the established twelve-step system, and all manuals of the art be compiled on a notation implying that human feet need move in no other ways. I will leave it to those who are perfectly satisfied with our existing pitch-notation, to say whether they think the measures I have hinted at would, if early adopted, have exercised a happy influence on the development of the ballet.

Whatever difference of opinion there may be as to the practical importance of the defects which have been pointed out, the existence of these drawbacks amply justifies attempts to remove them. The most important of these is embodied in the 'Tonic Sol-fa' notation, of which I propose to give a brief description for the sake of those who may not be acquainted with it.

The whole apparatus of staff and notes is discarded by this notation, and replaced by the initial letters of the time-honoured syllables, 'do, re, mi, fa, sol, la, si,' arranged in horizontal lines, as in ordinary letterpress. To avoid ambiguity between *sol* and *si*, the latter is altered into *ti*. A rise or fall of an octave is indicated by a superscript or subscript accent. Thus d^1 is an octave above d, d_1 an octave below d. Whatever key is employed, *do* always denotes the *tonic for the time being*, and *re*, *mi*, *fa*, &c. represent notes forming with it the successive tonic intervals of the natural *major scale*. Accidental tonic intervals are denoted by additional syllables. Modulation is indicated by an ingenious contrivance called the 'bridge-tone,' which exhibits at a glance the twofold relation borne by a note of transition to the outgoing and to the incoming tonic. Each relation is, of course, expressible by a proper interval-initial, and the displacement of one of these letters by the other symbolises the supersession of the old tonic by the new one. The 'bridge-tone,' constructed on this principle, places the retiring initial above and to the left of the entering one. Thus ^{d}s indicates the commonest

transition, that into the key of the dominant The '*do*' of the outgoing key is to be sounded, *but its name changed to 'fa.'* Immediately after a modulation, the old syllables resume their sway, but the notes indicated by them, being reckoned from a different starting-point, are no longer the same that they were before the transition occurred

This meagre outline, which is all that the time at my disposal allows me to give of the Tonic Sol-fa notation, yet suffices to bring out its two conspicuous merits. The intervals which it indicates are *tonic*, and they are *natural* Mr Curwen—who, though not the inventor of the method, has greatly improved and developed it (the bridge-tone is, if I am not mistaken, due to him)—is therefore entitled to a hearty recognition of the fact that the system with which his name is identified is free from the two most serious defects of the established notation

In a volume published about a year and a half ago,[1] I spoke of the Tonic Sol-fa system in terms of strong approval, but, while recognising its superiority as fully now as I did then, I think that there is one great advantage possessed by the established system which we cannot afford to part with. I mean its pictorial character, which appeals so directly to the feeling that we must go *up* to a shrill note and *down* to a grave one The sacrifice of this help to the mental conception of pitch I regard as the very opposite of an improvement on the old notation. Further, I am convinced that letters can never be read with the ease and rapidity attainable with notes of the ordinary shape The subscript and superscript accents are difficult to read, and very liable to misprints; and, what is still more serious, errors arising from this source are often *cumulative*—i e, a single mistake in an accent may throw everything which comes after it an octave too high or too low. The way in which every minor key is treated as a mere appendage of its relative major I consider very objectionable, and the special time-notation incorporated in the system appears to me, when applied to all intricate divisions, decidedly more complicated than that which it seeks to replace

Considerations such as those just laid before you induced Mr. W. H. Gill to seek to combine in a notation of his own the principal advantages of the established system and of the Tonic Sol-fa. He has published a short account of his method, to which he has given the name 'Tonic-Staff Notation' He employs a staff of *three* lines instead of five, and notes of the ordinary form, whose pitch, however, is not *fixed*, as in the old notation Whatever be the key employed, its tonic is always written on the *lowest line* of the staff Notes occupying the remaining spaces and lines represent sounds which form with the key-note the tonic intervals of the major scale When a modulation occurs, the whole staff is shifted bodily up or down, until its lowest line is coincident with the incoming tonic in the former position of the staff In

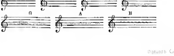
[1] *Sound and Music*, pp. 213-215. (Macmillan & Co.)

thus manner Mr. Gill's notation embraces the exhibition of natural tonic intervals and the retention of a pictorial scale of pitch. Further, by placing the second line of his staff sometimes nearer to the third than to the first line, and sometimes nearer to the first than to the third, he constructs two varieties—the former to be used for major, the latter for minor scales. The *principles* on which Mr. Gill has gone are identical with those of my own system, and I gladly acknowledge his priority in publicly stating and using them. At the same time I do not think that the modes of applying these principles which he has adopted are free from serious objection. To mention one or two of these.

It certainly seems undesirable, in a system avowedly 'designed as an introduction to the study of the ordinary staff notation, on the moveable *Do* principle,' to nail the tonic permanently down on the bottom line of the staff, because when once this association had been formed in a learner's mind, he would experience a great deal of unnecessary difficulty in reading off intervals from *any assigned line or space*, which he will in his subsequent established notation studies constantly have to do. It would be a frequently occurring consequence of the same arrangement, that before and after a modulation a note of one and the same degree of pitch would first appear on a line, and then in a space, or *vice versâ*—a circumstance likely to cause much confusion when the ultimate change to the established notation came to be made. The difficulty of writing music on this system appears to me all but insuperable, and I understand that its author does not contemplate its being applied to instrumental music. For those reasons I cannot regard his system, ingenious though it is, as a final solution of the problem.

In proceeding to describe that to which I have myself been led, I wish to state, explicitly, that while I maintain the principle of tonic relationship embodied in the system to be both sound and complete, I make no such claim on behalf of the expedients here proposed for carrying it out. These are mere tentative suggestions, the utility or inutility of which nothing but subsequent experience can determine.

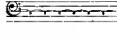
The five-line staff and the clefs commonly used are retained unaltered. *The position of the tonic for the time being is indicated by a wavy line drawn along the appropriate space or line of the staff.* This is the essential feature of the system, and must therefore be illustrated by an adequate number of examples.

The seven so-called 'natural' keys are provided for by this method, as follows:—

For 'sharp' and 'flat' keys—*i.e.*, those whose tonics do not appear in the scale of C major—the form of the wavy curve is modified, loops turned upwards being used for the former, and downwards for the latter.

Thus

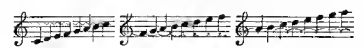
indicates the key of F♯,

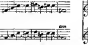
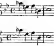
that of B♭. Similarly



and

denote the keys of D♭ and C♯ respectively.

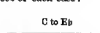
Notes standing without any sign of pitch-modification prefixed to them belong to the major scale of the reigning key-note, and are to be read off according to their distances from the line or space occupied by the tonic curve. Thus the scales of C major, F♯ major, and A♭ major would be written as follows:—

Minor tonic intervals are distinguished from such as are merely 'accidentally' modified intervals of the major scale by a special symbol (L) prefixed to them. The descending minor scale, in its ordinary form, is written as follows for the keys of C, C♯, and B♭:—

The signs ♯ and ♭ are exclusively reserved for *chromatics*, and with this limitation on their ordinary scope that *they only influence those notes to which they are actually and immediately prefixed.* The sign ♮ is by this convention rendered superfluous, and may be dispensed with altogether. I append two chromatic phrases, written in the established notation, with a translation into my system beneath each :—

Whenever a modulation occurs, the tonic curve correspondingly shifts its position, or alters its form, or undergoes both these changes at once. The following are instances of each case :—

C to G

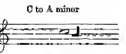
D to D♯

C to E♭

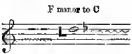


It has already been seen that, at a modulation, a note of transition stands in a twofold relation to the outgoing and to the incoming tonics. If the new relation admits of being expressed by a major interval, the notation itself shows what that interval is. We have, of course, only to count it off from the new tonic curve. If, however, the interval in question be minor or chromatic, the fact can be indicated by writing immediately *after* the note of transition an appropriate symbol—*e.g.*, ⌋ in the former case, and an 'accidental' in the latter. For instance :—

C to A minor



F minor to C



Only one point remains to be explained. We are familiar with cases in which a *change of notation* indicates *no change of pitch*. Thus, C♯ may be replaced by D♭, or *vice versâ*, though the note to be sounded remains the same. When such a change affects the tonic itself, there is, of course, no real alteration of *key*, but only of key *notation*. To call such a change a 'modulation' (as is done in the phrase 'enharmonic modulation,' commonly applied to it) is extremely misleading, since it tends to confuse together two things which ought to be carefully distinguished

from each other—viz., a change of *pitch* on the part of the tonic, which alone constitutes a modulation; and a mere change of *notation*, existing only on paper, which therefore is no modulation at all. In my system an enharmonic change involving the tonic is shown in such a way as to prevent its being mistaken for a real modulation. If a transition note is sounded both before and after the change of notation, a straight line is drawn from its first to its second representative, to show that no alteration of pitch is contemplated. In the case of a note entering without this kind of preparation, a straight line is drawn to it from the position on the staff which it would have occupied if it had been written down before the change took place. The following are cases in point:—

The system above described gets rid, by the expedient of the tonic-curve, of all ♯s and ♭s, save those which indicate notes really extraneous to the major scale of the key-note in use at the time. In the established notation every major key at all remote from that shown in the signature brings in several ♯s, ♭s, or ♮s, the result being that it is often no easy matter to tell whether a particular note stands in a major, minor, or chromatic relation to the reigning tonic. The simplification which I advocate removes every such superfluous symbol, and also sweeps away the cumbrous key-signatures. The saving thus effected in the number of signs of pitch-alteration employed will, of course, vary with the composition to which the system is applied. In some very extreme instances I have found it amount to as much as 90 per cent.; in all cases where any considerable use of modulation is made, it will not, I am persuaded, fall short of 50 per cent. Every musician knows what a relief is experienced when a transition into a remote key is accompanied by a corresponding change of signature. My notation secures this advantage at every step of a composition, without demanding the constant effort of memory which rapid successive changes of signature would necessarily entail. The key-note stares the performer in the face throughout, and relieves him of all responsibility save that of remembering the invariable construction of the normal major scale.

To the singer my system offers all the advantages of the Tonic Sol-fa, while it preserves for him the pictorial exhibition of pitch and the superiority of notes over letters which that method sacrifices: it also provides a satisfactory continuous indication of absolute pitch, which, though not indispensable to a vocalist, is at least convenient for the sake of comparison with the notes of an accompanying instrument.

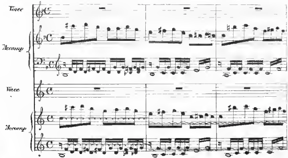
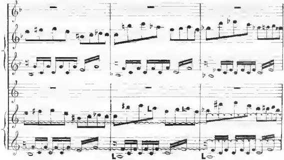
To the pianist and organist the main advantage derivable from it would lie in the removal of superfluous symbols, on which I have already dwelt. Still, I cannot but think that in their case, too, though to a less extent than in that of a singer, the fact of the major, minor, or chromatic character of a composition being constantly prominent on the face of the notation, and notice of every modulation being given as it occurred, would assist the intelligent performance of difficult works.

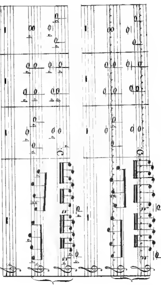
In order to facilitate comparison of my system with the established notation, I place here a portion of No 11 of Spohr's 'Last Judgment,' written in both methods The upper three lines of each bracket of six contain the established version, the lower three the simplified version The number of accidentals, ♯s, ♭s, and ♮s, required by the old system, exclusive of those in the key signature, will be found in this instance to be 181, while 56 signs of pitch-modification suffice to represent the same extract in mine.

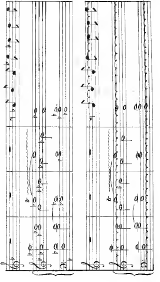
At the conclusion of the Paper the thanks of the meeting were unanimously voted to Mr Sedley Taylor; and a discussion arose, in which the Rev T Helmore (the Chairman), Dr Stainer, Dr Pole, Dr Stone, Mr Charles E. Stephens, and Mr. Alexander J Ellis, took part Mr Sedley Taylor replied.

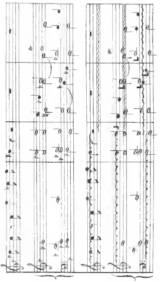
Mr Sedley Taylor having represented to the Committee of the Musical Association that the illustrations appended to his paper in the Proceedings for the Session 1874–1875 are rendered all but useless on account of the tonic curves—an essential part of Mr. Taylor's suggested system—being inaccurately placed upon lines and spaces, in consequence of difficulties inherent in the mechanical process adopted, the Committee have consented to have a new set of illustrations executed by another process, under Mr. Sedley Taylor's personal supervision.

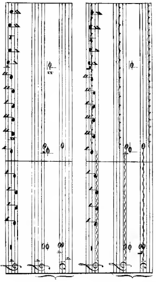
These are herewith forwarded gratuitously to members of the Association

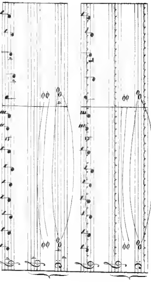
From Spohr's Oratorio the Last Judgment No 11



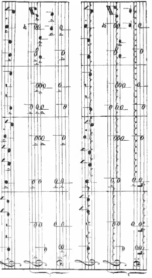


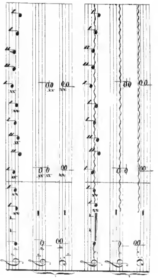


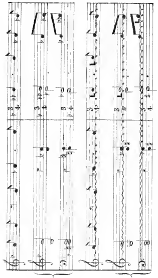
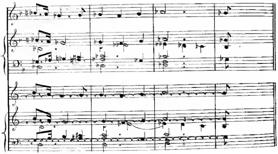










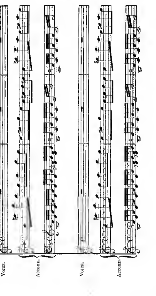
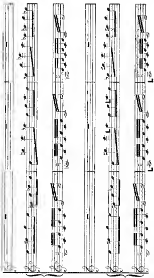
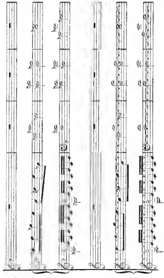


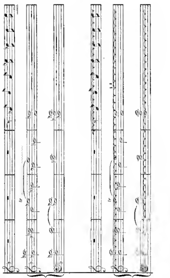
To the pianist and organist the main advantage derivable from it would lie in the removal of superfluous symbols, on which I have already dwelt. Still, I cannot but think that in their case, too, though to a less extent than in that of a singer, the fact of the major, minor, or chromatic character of a composition being constantly prominent on the face of the notation, and notice of every modulation being given as it occurred, would assist the intelligent performance of difficult works.

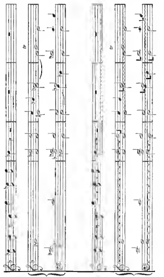
In order to facilitate comparison of my system with the established notation, I place here a portion of No. 11 of Spohr's 'Last Judgment,' written in both methods. The upper three lines of each bracket of six contain the established version, the lower three the simplified version. The number of accidentals, ♯s, ♭s, and ♮s, required by the old system, exclusive of those in the key signature, will be found in this instance to be 181, while 56 signs of pitch-modification suffice to represent the same extract in mine.

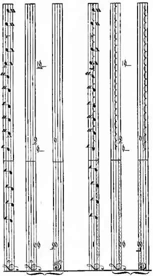
At the conclusion of the Paper the thanks of the meeting were unanimously voted to Mr. Sedley Taylor, and a discussion arose, in which the Rev. T. Helmore (the Chairman), Dr. Stainer, Dr. Pole, Dr. Stone, Mr. Charles E. Stephens, and Mr. Alexander J. Ellis, took part. Mr. Sedley Taylor replied

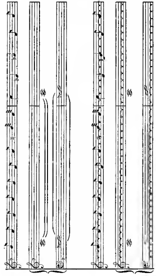
FROM SPOHR'S ORATORIO, THE LAST JUDGMENT—No. 11.

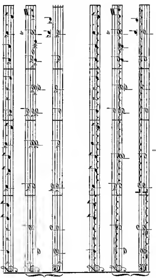


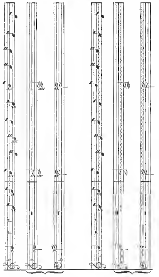


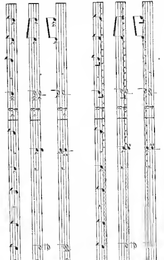


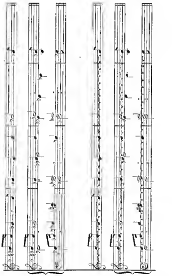












MESOTONIC HARMONIUM.

MR. ALEXANDER J. ELLIS, F.R.S., exhibited a Mesotonic Harmonium, the invention of Mr. T. W. Saunders, of E Lachenal's Concertina Manufactory, 4, Little James Street, Bedford Row, W. It had five octaves and two rows of vibrators. By drawing out a stop, the pitch of any single note could be altered throughout the five octaves, and on pushing it in, the original pitch was restored. As arranged when all the stops were in, the instrument sounded the seven naturals and five sharps. By drawing out a stop G sharp became A flat, and so on. By this means the instrument would play in from seven flats to seven sharps with the precise mean-tone or mesotonic intonation, so-called because the interval of a tone is exactly a mean between the major tone and the minor tone. The consequence of this is that every fifth is a quarter of a comma too flat (on the ordinary piano the fifth is one-eleventh of a comma too flat), the major third is precisely in tune (on the ordinary piano it is seven-elevenths of a comma too sharp), and the minor third is a quarter of a comma too flat (on the ordinary piano it is eight-elevenths of a comma too flat). The consequence is that the chords are very much finer and more agreeable than on the ordinary harmonium, being the same as in the old organ-tuning as far as it went. The fingering remains unaltered. The construction can be utilised for producing a justly intoned harmonium with Helmholtz's intonation, but having only one manual and the usual fingering.

JANUARY 4, 1875.

WILLIAM SPOTTISWOODE, ESQ., M.A., F.R.S., LL.D., VICE-PRESIDENT, IN THE CHAIR.

ON THE APPLICATION OF WIND TO STRING INSTRUMENTS.

By J. BAILLIE-HAMILTON, Esq.

THERE seems to have been a feeling in all times, that the combination of wind and string in music would afford some strangely beautiful result.

The very words themselves suggest many pleasing ideas, and these are, to a great measure, embodied in the string of the Æolian harp.

There we have a string excited by a natural draught of air, which is sufficient to stir it without restraining those vibrations which afford the sweet but fitful series of Æolian sounds.

But all efforts that have been made to secure and confine these sounds have destroyed their sweetness with the very means that destroyed their freedom, and so this string became almost the symbol of what is most beautiful and most uncontrollable.

It is my task to-day to show what are the prospects of recovering to our use this source of sound.

Many efforts have already been made, and their history would furnish material for many interesting lectures; but there is only one branch of these efforts on which I am in any way qualified to speak, and it is that in which the materials used are a 'reed' and a string.

The history of previous efforts may be briefly described as different modes of concentrating an artificial draught of wind upon the whole or part of a string; generally the string so exposed was flattened to increase the 'bite' of the wind, and this flattened portion set over a corresponding slit.

Mr. John Farmer, our organist at Harrow School, hit upon the original expedient of using the tongue of a 'free-reed' for this purpose, and by connecting its extremity with a string, discovered that they did not necessarily interfere with each other's vibration, and that the string thus moved could be controlled by 'stopping,' as in a violin.

For a long time this string was seen, and admired, and wondered at; but those familiar with experiments in sound will readily understand how these are incompatible with the pursuit of an important profession, like Mr. Farmer's, and how it was not possible for him to develope this discovery to its fullest results.

At the same time, it is clear that when once these materials are used, there is no longer any room for a claim of originality left for others, but only that patience and disregard of difficulty and opposition necessary to carry out such an undertaking.

In speaking before an assembly of men who are all my seniors in age, and most of whom I regard as my teachers, my only ground of confidence lies in the fact that the subject is at any rate worthy of your attention, and may receive the benefit of your experience.

The 'reed' plays such an important part in all the experiments that are to be shown, that it will be well to describe its action at starting.

The reed employed is similar to that which produces the notes in harmoniums.

It consists of a tongue of metal vibrating from a root, and having a definite pitch.

It is set in motion by a draught of air which is concentrated by passing through a hole corresponding in size to the tongue which is set upon it.

The draught of air, as a rule, must tend to force the tongue into this cavity, and, as the tongue acts almost like a piston, it succeeds to a certain extent—sufficient, in fact, to act as a pinck or artificial forcing from its position of rest

After a certain point the elasticity of the tongue reasserts itself, and bursts through the opposing current of air, which again controls it when its return-stroke is exhausted. Either pressure or suction may be employed as long as the tongue is forced into the mortise of the reed

But there are many other conditions necessary to create what is termed 'true suction' on the reed, and which are a constant source of difficulty to the experimentalist

In this undertaking the function of a reed was originally meant to be that of a 'bow,' and the reed was at first attached to the end of a string—forming, in fact, a prolongation of it But it has been found advisable to set it in a different level, so that both reed and string may be respectively in their best conditions. The connection is effected by a rigid pin starting from the free end of the reed, and attached to the string at any point required. Used as a 'bow,' the reed contributes new possibilities, but also new difficulties

In an ordinary string the nature of the bow does not, of course, affect its pitch. But a 'reed,' when used in this capacity, enters into the composition of a string to such an extent, that a series of reeds applied to a string whose condition is constant will afford a series of entirely different results The intervals, moreover, on this string will vary with every reed applied. Besides this, there is only a certain amount of string controllable by a certain string, and if this amount be exceeded, the string either refuses to speak, or breaks up into segments, thus rendering all control by the fingers impossible.

There is only one thing required to meet all these difficulties,

and that is *the proper relation of string and reed.* The study of this one point would afford labour for a lifetime, and though I do not profess that this relation is already attained—in fact, I am glad that so many possibilities are still unexhausted—yet there is sufficient to show that this relation *may* be obtained, and the indications which were followed in seeking to obtain it are so interesting, and throw so much light on the laws of reeds and strings, that the experiments to-day will be chiefly confined to this point.

There was a time when little experience could be brought to bear on this subject, and when but a few notes could be obtained from a rudimental sort of wind-fiddle—and when, in order to gain the means and the liberty to carry on this undertaking, something more than this had to be shown. Accordingly, all efforts were concentrated upon producing some sound, which, by its merit as sound alone, would vindicate the worth of the principle.

It is clear that one reed and string might produce a single note, controlled by a key, as well as afford a series controlled as in a violin. Accordingly attention was turned to this point, as forming directly an organ, and indirectly acquiring experience to make a violin such as will, I hope, be shortly finished. The strings were stretched on a soundboard, and the reeds were set in their best conditions in a wind-chest below. At last some notes were obtained, far surpassing all other ones in power and beauty, and in all these instances it was observed that the string was resolved into nodes and segments. All segments afforded a note of the same pitch, and were equal in length, except that one in which the reed lay, and which is termed the "reed-segment," and varies in relation to the others in accordance with the excess or deficiency of the reed as a load.

Here are some such notes: you will observe that in intensity they are equal to or greater than this organ-pipe, which I sound with them. As regards quality, it is possible to obtain these very sounds, which baffle the organ-builder—such as a real string sound, a pure soft horn, Æolian sounds, and certain harmonic and voice-like tones peculiar to wind and string.

I show instances of these few sounds as being peculiar to this instrument; the remaining qualities, which resemble those already known, will, I hope, be soon shown in a complete instrument, and controlled at the will of an organist.

The most pure and intense sounds occur when the string is resolved into segments.

It will be seen that the segments all afford a note identical with that executed by the reed, and as the terminal segments are free, and appear to execute only a simple vibration, it would seem that they contribute an additional fundamental; at any rate, they secure by their intervention that natural relation of reed and string in the central segment which there was then no human experience to determine and arrange. If this be so arranged, and there is only one segment, the *quality* will be the same as if the terminal segments were present; but until further

experience is gained to deliberately plan this relation, there is a danger of losing that smoothness and perfection which Nature thus ensures when resolving the string.

In dealing with quality, only one segment need be considered, *i.e.*, the 'reed-segment;' the others may or may not be present.

It is impossible to give any rule that would define the exact means of gaining various qualities, but the broad rules are as follow:—

1. When the excursions of the reed are small the tone is smooth and liquid, like a flue-pipe.

2. When the excursions are large the tone is more coloured, like a reed-pipe.

3. The intensity of the string element depends on the mechanical power of the string over the soundboard, either by high tension or swaying motion.

4. The intensity of the reed element depends upon the condition of channels, &c. which naturally reinforce a reed.

The combinations possible by the application of these four rules evidently admit of great variety. But this will be best proved hereafter, in a complete instrument.

It is now only necessary to point out the practical results which are likely to occur. When instruments having a keyboard are employed, we must consider the principle as involving rather the application of strings to wind (*i.e.* reed) instruments, than the application of wind to string instruments.

I have shown that a string can equal an organ-pipe in intensity and quality of tone. A common soundboard suffices for a whole series of strings, whereas a separate pipe is required for each note of a series so produced: in fact, each note of an organ now requires a special reinforcement (*i.e.*, a pipe), whereas in a string organ the *general* reinforcement of a common soundboard reacts upon the reed as a *special* reinforcement through the medium of the string, as was explained before.

It is needless to point out the economy of using a string instead of a pipe, and the beautiful form which a series of such notes might be made to assume. There is, moreover, a sympathy in string sounds, and certain influence which is better known than described, so that the human voice turns to them for support, and the human ear for satisfaction. And if no other tones could be gained beyond those now in use in organs, yet if these were produced by strings, I believe their effect upon a choir of voices would be almost incredible, judging from the results which a few such experiments have shown.

But there are other requisites in an organ besides beauty of sound and form, and economy of space; there must be prompt control of sound, and there must be preservation of tuning. A string organ must, it would appear, share the liability of strings to get out of tune. But there is no necessity for strings when at a low tension, and undisturbed by any concussion, to vary to any great extent. But supposing this were the case, the following device may be employed:—If an elastic band be stretched

it will afford a note, when plucked, which will not vary until its elasticity is almost exhausted. It will then vary rapidly, with tension, like an ordinary string. This will be the case with a metal string until its elasticity be exhausted, and this may be preserved by modifying the string into a coil, or where a coil is inadmissible between the bridges, by setting a few inches of a tempered and coiled string beyond the bridges, so as to act as a *compensator*.

As regards quickness of speech, it is clear that whatever will excite a string will excite it when attached to a reed, and as the *sound* does not depend on this excitation, the percussion employed may be of the most rudimentary description. But it is found by experience that in this case, as in all others, the proper relation of reed and string solves the difficulty, and prevents any *interference* of the combined elements with each other.

But there is one point in which the meanest harmonium surpasses the grandest organ, and that is in the power of *expression*. If in an organ-pipe we attempted to vary the force of a note by the force of wind, the results would be disastrous. But neither reeds nor strings vary their pitch with the intensity of their vibrations. Accordingly a pure and intense sound can be made to tremble and thrill, and swell and fade away, at the will of the organist. And if ever any of us, who have hitherto worked almost without hope, are allowed thus to hear these sounds satisfying the ear and sustaining the voice, it will be sufficient reward for the labour, and still more the doubt and suspicion, that must necessarily attend an undertaking which so many ages have condemned as hopeless.

DISCUSSION.

The Earl of WILTON enquired whether a note produced on Mr. Hamilton's principle could answer as instantaneously to the touch as in the common organ, where the air is always ready to pass through the pipe that gives it. It appeared as though the string would have to be set in vibration first.

Mr. J. B. HAMILTON replied that the objection was a most reasonable and natural one, and the one which he had hoped would be brought forward first. It would be seen that with the apparatus in the room he had no means of controlling the note, and he had had some difficulty in getting it to speak at all. The reason was this, that the string had to resolve itself into an artificial form. When this could be done all difficulty was at an end. He had no means at hand of doing it artificially. This had seemed an insuperable difficulty at first, and he had not seen how to get over it until the difficulty had been investigated. He had feared at one time that a piece of music might have to be played several hours if it was wanted to be heard, and that Evening Service would have to be got over in the morning,

about which there would be many difficulties. But there was a simple way of doing it. On the form of the vibration depended the note, and it was necessary, first of all, that the string should be resolved into this form, artificially. If the string were set in vibration, it had to hesitate whether it would divide itself into the form which it would ultimately assume, or vibrate in its entirety. That was the reason of the delay of the string in speaking. Artificially, however, that difficulty could be overcome. The note was not at all interfered with by being touched or damped at either of the nodes, and thus the vibration could be artificially guided. He had put at the end of the room a sort of diagram of the appearance which a row of pedal-notes would present in an organ. It was a full-size diagram of the pedal harp, down to a sixteen-feet tone. In ordinary cases, where reeds or closed tubes were used, and the action was carried through the little channels which create the draught upon the reeds, the reeds were not at all seen; all that was seen being just the exit, which the red wafers on the diagram represented. The second slanting line on the diagram was a string, which was stretched across all the nodes, because of course, in a series of strings like that, all the nodes could easily be brought to form a straight line, and across that nodal line there was stretched an elastic string. The best sort to use was horsehair, or something of that kind, because you there get really a 'hair's breadth.' But any stiff string put across at the proper tension, so as to touch the nodes of all the strings, would answer the purpose. In the first place it acted as a damper, and controlled that point and kept it steady, without interfering with the resonance of the string in any way, but rather helping it, and steadying the string. But its most useful function was that it transmitted the vibration. If a single note of that series were made to sound, all the reinforcing segments, all the lower halves of those strings, would be thrown into vibration. The notes would not sound, because the unequal segments were still embarrassed by the reed, but directly the reed is released, and the draught came upon it, the string would fly into vibration in a moment. There was something already controlling the string, and the result was that harp-like sound, that is like one great string, when one note was made to sound, and you could glide down from one note to the other like one string without employing any percussion on the string above. On the other hand, when using a string you could use another mode of percussion which was already applied to strings, and as you did not rely upon percussion for the whole sound, it could be made of the most rudimentary description. If the string refused to speak, almost any kind of percussion would set it going if it were resolved in this way, by being damped at the node. Mr. Hamilton believed no difficulty would ultimately arise from this cause, but that, on the contrary, there would be advantages from the sympathy of the different strings.

The Earl of WILTON asked whether any of these strings were in contact.

Mr. Hamilton replied that they were not.

The Earl of Wilton asked whether they were all metallic.

Mr. Hamilton answered—Yes.

The Rev. Mr. Helmore asked whether the blast could be regulated so as not to sharpen or flatten the notes.

Mr. Hamilton replied that that was a second objection. If the pressure of wind in an organ varied considerably, you would not get a perfect quality of sound. If he were to vary the wind on an organ-pipe, it would not sound truly; but if he varied the blast upon a string, it would not vary in pitch, as would be heard. [*Illustrating same.*] It varied a little in characteristics, because there was a great deal of sound, which was not due either to the reed or to the string, but arose from the wheezing through the holes, which came out with great predominance at one point. The pitch did not vary, for this reason. The motion of reeds and string were both isochronous; you could increase the amplitude of vibration without altering the pitch either of a string or reed, therefore an increase of force applied to it would simply increase the sound without altering the position of the reinforcing body. In an organ-pipe a greater pressure of air, it was believed, drove the nodes farther up the pipes, and thus made a slightly sharper note.

Dr. Veerinder asked whether the reeds were tuned in unison with the strings.

Mr. Hamilton replied—No; that was done almost in the dark. It was done quite empirically, because it was impossible to devise a unison beforehand. The pitch of the reed and of the string was altered by combining them, so that you had to provide that they should have some common action.

The Chairman felt sure that he had been anticipated in proposing a vote of thanks to Mr. Hamilton for his very original communication, as well as for the illustrations he had been able to furnish. Notwithstanding the difficulties he had already explained, he (the Chairman) felt sure that the subject was one which would not only occupy all present this evening, but engross the attention of musicians and students of acoustics for many a long year to come. Many members would, no doubt, wish to offer some observations, or put some questions to Mr. Hamilton.

The Earl of Wilton had much pleasure in seconding the vote of thanks.

Mr. J. Hullah enquired what variety of *timbre*, answering to the varieties of stops in an organ, Mr. Hamilton hoped to attain. It was a very large question, and perhaps hardly a fair one to put.

Mr. Hamilton said it was such a large question that he could only answer it by saying that the variety was obtained according to the predominance of the reed on the string. A reed by itself always contributed something reedy; the reediness is owing to the opening and shutting, the largeness of excursion of the reed. A reed depends for its intensity on the largeness of its excursions, and largeness of excursions means intensity of tone. But in this case the reed did not at all rely upon itself for intensity,

but on the reinforcing segment of the string, and this so modifies it that all the reediness was removed; so that even when the reed was allowed to predominate, it did not follow that you merely get a gigantic harmonium effect. It meant that it passed into the more mingled effect produced by the reed predominating more than the fundamental. When the reed was ruled by the string in its segment, it was like a column ruling a reed, and produced a flue-pipe effect. In strings, and the same with pipes, there were only two points from which to start—namely, where the column reacts upon its initial sound, where the initial sound is more independent of the column. All the varieties which could be gained in that way he could hardly describe, and, in fact, the only answer he could give would come later, when he would show the qualities produced.

Mr. J. HULLAH said he would put his question in a concrete form. He believed Mr. Hamilton was building an instrument on the principles he had laid down; how many *stops*, to use a common expression, would he propose to have in it?

Mr. HAMILTON said that at the present moment he had qualities for at least thirty distinct stops.

The Earl of WILTON believed that the difference in sound of a hautboy and a clarinet, and the small amount of harshness which is there noticed, was in consequence of the reed having only half-motion. Was not that so?

Mr. HAMILTON: Yes, a 'beating' reed naturally affords a harsh sound by itself.

The Earl of WILTON enquired whether what he called 'the reed' passed freely through the aperture.

Mr. HAMILTON said that here was broached a very deep question, one which he would not willingly have entered upon, because it did not affect the philosophical part of the subject. But it very vitally affects the mechanical part. He believed that a reed only sounded in the back-stroke. The pitch of a reed, when blown, was certainly the same as when sounded as a reed; but in the forward-stroke of the tongue it was going at the same rate as the draft, and there could therefore be no sound, but the sound is reduplicated in the return-motion against the draft. A reed might be said only to sound functionally, when it returned against the draft in the back-spring. But we were not bound to use one string and one reed; there was the clue to the solution of the question.

Mr. SEDLEY TAYLOR, M.A.: Mr. Hamilton had said there were two segments of the strings which were of unequal length. Had he ascertained, by measurement or calculation, that the sounds reinforced by these loops coincided exactly with the fundamental of the general note produced?

Mr. HAMILTON said that could be easily ascertained, by putting a bridge at either of these nodes and starting the note.

Mr. S. TAYLOR asked whether it was the fundamental sound, or one of the overtones?

Mr. HAMILTON said it was identical with the fundamental sound.

Mr. S. TAYLOR: Then you never strengthen any of the overtones, but always the fundamental?

Mr. HAMILTON: Always the fundamental. It was quite possible for the overtones to take care of themselves. For instance, suppose he wanted the overtone to predominate, he should weaken the fundamental, and leave the overtones to take care of themselves. In an ordinary reed this would be offensive, because if the reed went through a larger excursion it would leave nothing but reedy sound. Here, however, the reed was controlled by being attached to a string and purified, and therefore it was quite safe to leave the reed-segment to itself. If he cut off the two fundamental segments, that left a very pleasing and beautiful sound out of the reed-segment alone; therefore he could arrange to have almost any colour he liked predominating without offensiveness.

Professor MONK: Was it found possible to strengthen the overtones as well as the fundamental?

Mr. HAMILTON: It was, because if he weakened the fundamental, that of itself strengthened the overtones.

Mr. A. J. ELLIS, F.R.S., said that if he understood the harp diagram properly, Mr. Hamilton had cut off the top segment altogether?

Mr. HAMILTON: Yes, for convenience, because one reinforcing segment was found to be sufficient.

Dr. VERRINDER wished to understand whether the reeds were exactly in the same form as in an harmonium.

Mr. HAMILTON: Not necessarily.

Dr. VERRINDER: Were the strings tuned in the same way corresponding with the reed?

Mr. HAMILTON said it was impossible to devise the unison beforehand with reeds and strings. He would show afterwards that some of these high notes were produced by quite low-tenor reeds.

Dr. VERRINDER: The strings did not speak in sympathy with the reeds.

Mr. HAMILTON: When resolved, one part of the string was in sympathy with the reed, and that was the necessity for the nodal line.

The CHAIRMAN asked whether it would be a correct explanation of that peculiar mode of subdivision of the string to say, as Dr. Stone had suggested to him, at the beginning of the meeting, that the energy of motion of the shorter central segment, plus that of the reed, was equivalent to the energy of motion of each of the longer segments at the end of it—that you really had the whole apparatus divided into three harmonious segments, each of which would have the same energy of motion?

Mr. HAMILTON said that was perfectly true, because, although the amount of string was not in unison, yet the whole mass of the central segment was in unison with the longer segments

FEBRUARY 1, 1875.

JOHN HULLAH, ESQ., VICE-PRESIDENT, IN THE CHAIR.

ON THE FALLACIES OF DR DAY'S THEORY OF HARMONY, WITH A BRIEF OUTLINE OF THE ELEMENTS OF A NEW SYSTEM

By CHARLES EDWARD STEPHENS, ESQ.

(*Abbreviated.*)

In the present state of scientific knowledge in general, it may appear incomprehensible, to those who have not pursued it in the direction of music, that we should have arrived beyond the middle of the nineteenth century of the Christian era without any work having yet appeared which has set forth even the elements of that science in a light which has carried conviction and met with general acceptance. I am not speaking here of the excellent treatises of Sir John Goss, John Hullah, Henry Lunn, Henry Banister, Alexander Hamilton, &c. These, and numerous others, do not profess to treat of the recondite view of the subject, but solely to supply the young student with practical applications of accepted facts. What is still wanting, despite numerous endeavours, is a work which shall convincingly trace the materials and combinations of the Harmonist to their true source, and show him (as I believe to be the case) that those materials and combinations are not arbitrary and conventional, but are supplied by Nature herself—thus enlarging his views, and, in fact, laying before him all of which, as a Harmonist, he can avail himself.

The earliest serious endeavour to this end was one which, considering the general state of scientific musical knowledge at the time, reflected the highest honour on its author—Rameau. He had predecessors (and notably Zarlino, Mersenne, Descartes), who had pointed out the intimate relations between numbers and certain acoustical phenomena known as harmonics; but Rameau thence proceeded to the construction of secondary harmonies, by the arbitrary addition of thirds. It will be found that the addition of thirds is precisely what *does* happen in the constitution of chords, but, with Rameau and numerous of his successors, these thirds were simply assumed, not derived; sometimes they were superposed, and sometimes *sub*posed; and there was no basis for their selection, beyond the circumstance that they were convenient to make up combinations of which the ear approved, and thus the principle of harmonic generation, with which such theorists started, was afterwards set at naught.

It is not my purpose—indeed, time would not permit me—to even faintly trace the history of the science, and to show you how successive didactic writers thereon made attempts to supply *data* which they imagined to embody the truth, or all that they deemed necessary thereof The name of such writers is Legion. They all differ in important points in their views of the subject, and they furnish countless diversities of opinion between two extremes—one of which is perhaps represented by M le Baron Blein, who excludes every consideration which cannot be supported by acoustical phenomena; and the other by Gottfried Weber, one of the chiefs of the army of unbelievers, who, even in his own work on Theory, admits that it embodies no theory at all, and says that the little we know of truth consists only in observation of what sounds well or ill in such or such combinations of notes, and that all attempts to deduce these logically on a fundamental principle, and to transform them into a philosophical science or system, are vain.

It is more than probable that the labours of the vast majority of these writers have long since ceased to exercise any direct influence, but within our own time it was reserved for Dr. Day—a gentleman in the medical profession, but also of very extensive general attainments—to make one more attempt, which is the chief subject of my address this evening The Day theory is based on the general assumption that any note which can be used in connexion with any particular key must have an absolute existence in that key, and that this applies not only (as previously taught) to diatonic, but also to chromatic notes This is, briefly stated, the ruling speciality of this theory It had doubtless struck its author that in music (modern music especially), in any given key, we frequently find chords comprising notes not in the diatonic series in that key. Such chords must be very familiar to those here present; such as, for instance, in the key of C major, chords comprising what is called the raised fourth of the scale—F sharp; similar chords, with also an E flat; various chords in which an A flat appears, chords known as those of the Extreme Sixth, with an A flat and an F sharp, and sometimes also an E flat, combined; chords containing an A flat and a D flat, such as that popularly known as the chord of the Neapolitan Sixth, and some others These chords comprise, in the aggregate, every note special to the chromatic scale, and Dr Day evidently felt that the mere cataloguing of such combinations as chromatic chords, without attempting to supply their derivation, was altogether unsatisfactory. At the same time, the transient way in which they are mostly used not appearing to him to justify the idea that they involved any change of key, he betook himself to diatonic roots in the key, whence these chromatic notes and chords could, as he thought, be derived, and so be brought within the key The roots which he adopted for this purpose are the tonic, the dominant, and the supertonic—*i.e.* C, G, and D, in the key of C; and superposing third upon third,

and pushing the assumed availability of the harmonics to the extreme limit of the interval of the thirteenth, he established his theory of fundamental chords on those three roots, comprising (all with major third and perfect fifth) chords of the minor seventh, the major and minor ninths, the eleventh, and the major and minor thirteenths, which chords include every chromatic note I have already named. The reasons which he gives for taking these three notes as roots, and no others, are, in his own words, '*Because the harmonics in Nature rise in the same manner: first the harmonics of any given note* [C], *then those of its fifth or dominant* [G], *then those of the fifth of that dominant* [D], *being the second or supertonic of the original note.*' He then adds, as a reason for not pursuing this system further, and adopting the last obtained fifth [A] as a root, that it *is a little too sharp*. I beg you to particularly bear in mind these words, because they manifest a solicitude for correctness of pitch, which elsewhere Dr Day so utterly disregards. Curiously enough, too, this very note, which he here singles out as being too sharp, and consequently unavailable as a root in the key, is afterwards specially assigned by him as such, as we shall find in due course.

Dr. Day then proceeds to show the treatment of his several fundamental chords before named, and this treatment includes certain restrictions as to what succeeds them, so as not to confuse the tonality, and he maintains that these so-called fundamental chords, including, in the aggregate, an entire chromatic scale, are then strictly in and belonging to the key.

[*Mr. Stephens here illustrated on the Pianoforte as far as the Chords of the Ninth.*]

It has doubtless struck some who have followed me thus far, that the successive superposition of thirds, to constitute chords, leads, from this point, to combinations which, in their entirety, are simply intolerable. I should be taking a mean advantage if I were to suffer such a misinterpretation of Dr. Day to strengthen, even transiently, my case against him. The diagrams now before you give you those chords complete, in order that you may clearly see their alleged derivation; but in their practical use they are subject to certain restrictions (and notably to that which, as a general rule, prohibits a discord and the note on which it resolves from being heard at the same time), which restriction, I may observe, exists in all systems comprising such extreme chords.

[*Mr. Stephens here illustrated the use of the remaining Chords already spoken of.*]

You will thus have found that, formidable as some of these chords in their entirety appear on paper, whon certain notes, in accordance with certain principles, are eliminated from them, they furnish, with their less formidable-looking brethren, an explanation, according to Dr. Day, of many things which are very common in musical composition, and are certainly not satisfactorily accounted for by other theorists. But, at the very outset,

we find that—although presumably only after many anxious endeavours to discover a better path—Dr. Day brought himself to adopt sounds, not for what they really are, but for just what he wanted them to be. The very first chromatic note at which he arrives is the so-called harmonic minor seventh, from the tonic root—the '*son perdu*' of Rameau—the '*bête noire*' of theorists in general—nominally B flat. And here, at once, the head and front of my objections will be anticipated. The so-called B flat, so obtained, is not the B flat which is available in the scale. It is, as you are all doubtless aware, too flat for any position in that scale. It is not a true major third under D; it is not a perfect fifth under the true subdominant; it is not in the ratio of a minor third with the dominant, &c., &c., and it is simply unusable. I will not, however, dwell longer on this particular seventh, since the partisans of Dr. Day may perhaps take refuge for a moment, and urge that when it is used *in the key of C*, and not to effect a modulation into that of F, it ought, perhaps, to be of the lower pitch of the harmonic minor seventh; so I pass on at once to Dr. Day's next fundamental chord of the seventh—namely, that on the dominant root, G, consisting of G, B, D, and F. Here, again, we find the harmonic minor seventh too flat. It is not the true subdominant F in the scale, a perfect fifth below C, and it is simply, like all the harmonic minor sevenths, unavailable. This will be doubly obvious in Dr. Day's remaining fundamental chord of the seventh, namely, that on the supertonic root, consisting, in the key of C, of D, F sharp, A, and (nominally) C. Here again, of course, the harmonic seventh (nominally C) is flatter than the true C of the scale. To 1,039½ vibrations of the former there are 1,056 of the latter; and so this harmonic minor seventh on the supertonic, declared by Dr. Day to be strictly in the key, *positively contradicts and is at variance with the key-note itself*. This instance clearly admits of no palliation whatever, and it is indeed, to me at least, marvellous that Dr. Day was not stayed by this startling anomaly, and thereby convinced that he was proceeding in error.

I have now to speak of the next chord in order, as derived by Dr. Day, from his three roots of Tonic, Dominant, and Supertonic—namely, his fundamental chords of the major and minor ninths, consisting of the chords of the minor seventh, just animadverted on, with the major or minor ninth added. In regard to the major ninths, that on the tonic root is the true note in the scale (the solitary instance of such truth in the whole of Dr. Day's sixteen deductions of discords from his three roots); but the major ninths on his dominant and supertonic roots are too sharp for the position assigned them in the scale. In regard to the minor ninths on the three roots in question, we find that to obtain even an approximation to the true sounds, we must travel in the harmonic series to no less an altitude than the fifth octave (the nodal point of $\frac{1}{17}$th of our stretched string), and

when at this altitude found at last, they are not in any one case of the pitch which Dr. Day assumes them to represent.

Up to this point I have been speaking of intervals which may, in one sense, be termed *flexible*—I mean which could, perhaps, be slightly out of tune without immediate detection by any but a keenly sensitive ear, but I now come to speak of another interval, the perfect fourth, which, under the name and at the distance of the eleventh, is the next note added by Dr. Day to his fundamental chords, constituting his chord of the eleventh, and comprising the intervals of his chords of the ninth, just considered, with that of the eleventh added. This chord of the eleventh, contrary to all the rest, he allows *only on his dominant root*, as I have already explained to you (with his reasons) when at the pianoforte. Now this interval, the perfect fourth in harmony, is one which you know has given theorists some trouble. Many have not known whether to class it as a concord or a discord, but two things, essential to our present investigation, are certain: the first is that the perfect fourth is not what I have, for want of a better term, called 'a flexible interval'; and the other is that no perfect fourth whatever exists as an harmonic from a root. Dr. Day's assumption of it, therefore, as one of the component intervals in his fundamentally-derived chords, is one of the most astounding things in his whole system. He is elsewhere urgent on the subject of roots—will admit of no combination which cannot be traced (at least according to his method) to a root or roots; and yet here, suddenly, in his chord of the eleventh, he discards his *alter ego*, and boldly adopts, as the chief characteristic of that chord, an interval which has actually no harmonic existence whatever. It has been urged, in extenuation, that this eleventh on the root is an expansion of, not a dereliction from, the principles previously established in the Day theory. How can we accept such an oblique and evasive plea, and, for the sake of mere expediency, admit that as a fact which is absolutely non-existent?

I now come to the last of Dr. Day's fundamental chords—namely, those of the thirteenth, comprising, on the *Dominant* root, the intervals of his chord of the eleventh on that root, with the addition of the major or minor thirteenth, equivalent, as far as the mere alphabetical name of the notes is concerned, to what are termed the major or minor sixth, but requiring different treatment as notes of Harmony. The systems of Derode and Sabbatini included also this interval of the thirteenth, and the latter termed it in that case the *dissonant sixth*. On the Tonic and Supertonic roots Dr. Day also places these chords of the thirteenth, but, as you have just heard, the chord of the eleventh not being admitted by him on those roots, his chords of the thirteenth thereon appear, as you see by my diagram, without the interval of the eleventh. Here is another striking anomaly. Dr. Day has built up his chords by the successive superposition of thirds; but, by rejecting these as the eleventh to his tonic and supertonic roots, his chords of the thirteenth on those roots

are denuded by him of one of the very links which led to their presumable existence. With regard to the thirteenths themselves, I will merely remark that, in all three cases, the major thirteenths, as derived by Dr. Day, are considerably too flat for the true notes in the scale; and as for the minor thirteenths, we find them not till we arrive at the sixth octave of Harmonics, and there, at last, at the high nodal point of $\frac{1}{51}$st part of our stretched string, are sounds again flatter than those as which Dr. Day adopts them.

It will have been found, from these remarks, that every harmonic beyond the third and fifth in Dr. Day's fundamental chords, has proved at variance with the note which he assumed it to represent, with the solitary exception of the major ninth on the tonic. But, further, not only do these Harmonics so contradict the true scale, but they necessarily present hopeless and irreconcileable contradictions among themselves. For instance, if the E, fourth space, treble stave, as deduced from the tonic root, gave 1,320 vibrations in a second, the so-called E, the major thirteenth from Dr. Day's dominant root, would be flatter, and give only 1,287 vibrations in the same time; while the so-called E, the major ninth from his supertonic root, is, on the other hand, sharper, and would give $1336\frac{1}{2}$, and thus we have no less than three different pitches supplied us by Dr. Day's roots in the key, for one and the selfsame note, and that the major third, in that key! Again, the note A, third space, treble stave, as derived by Dr. Day from his tonic and dominant roots, has 858 vibrations per second; while the A, as derived from his supertonic root, has no less than 891, thus supplying us with two pitches for the note A in the key of C, both of which, as it happens, are at variance with the true A of the scale. It is needless for me to further pursue this point, and show you the complete chaos which consequently exists among the intermediate intervals in Dr. Day's fundamental chords.

Dr. Day's chord of the eleventh on the dominant, of which I spoke in due order, leads me now to the consideration of what I conceive to be his utterly erroneous views (shared, however, by other modern theorists) respecting the subdominant and the subdominant triad. Every musician must feel the great value and importance of these constituent attributes of a key. The tonic and dominant triads, alone, do not, under all circumstances, positively determine a key; but with the addition of the subdominant triad, or even only the subdominant note added to the dominant triad, they do so, and, as I shall presently endeavour to prove, the note F, *as a root* in the key of C, and the triad on that F, are rightly termed by the older theorists sub-*dominant*, as constituting a determining and governing power in the key. Now although, in the earlier part of Dr. Day's work, he makes a transient admission of the subdominant as a root, yet, in the second part of that work, where his own speciality and idiosyncracies are more directly set forth, he distinctly tells us that

the *common chord* on the *subdominant* is to be considered as a *part of* his *chord of the eleventh* on the *dominant*. I must here remark, parenthetically, that it appears to me that when Dr. Day had committed himself to the adoption of the *supertonic* as a root in the key, he saw the difficulty of also including the subdominant as a root. Had he done so, he must have permitted the same chords thereon as on his other roots, and this would have brought about 'confusion worse confounded' It would have occasioned, for instance, the enharmonic diesis between the G flat, the minor ninth on this subdominant F, and the F sharp, the major third on his supertonic chords, and consequently one or other must, according to his own arguments, have been out of the key. But, besides this, the treatment of the chromatic chords so derived from the subdominant F as a root, would have been impracticable so as not to obscure or destroy the tonality of C. For these reasons, therefore, as it seems to me, Dr. Day, in this second part of his work, discards the subdominant as a root, and, as I have just observed, tells us that the chord of F, in the key of C, is to be considered as part of the chord of the eleventh on the *dominant* G—namely, the seventh (F), the ninth (A), and the eleventh (C). Now, as I have already shown you, the seventh, so derived, is *too flat*, while the ninth is *too sharp*, and the eleventh is simply assumed, having no harmonic existence whatever. Can we consistently accept that a chord, which is absolutely one of the determining and governing powers in connexion with the key, can be composed of such dependent, contradictory, and illusory materials as I have described?

The next chromatic chord with which I have to deal in Dr. Day's system is that familiarly known as the chord of the extreme sixth, on the minor sixth of the scale, comprising, in the key of C, an A flat and an F sharp, with C, or C and D, or C and E flat, to complete the harmony—these three forms of the chord being popularly known as the Italian, the French, and the German Dr. Day, finding it impossible to deduce these notes from a single root, offers a solution of the problem in a double root, thus —deriving the A flat as the minor ninth of his dominant root, G; and the F sharp, and the C, together with the D or the E flat, from his supertonic root, D. I need here only recapitulate that the A flat, so derived from G, is not found till the fifth octave of harmonics, and, when found, is not of the pitch assumed by Dr. Day Then, in the German form of this chord, the E flat, as derived by him from his supertonic root, is open to precisely the same objections, while, as we have already seen, the so-called C, common to all three forms of the chord, is, as derived by him from this supertonic root, distinctly at variance with the key-note itself.

The remaining chromatic chord which I purpose noticing in Dr. Day's system is his triad on the minor second of the scale—namely, on D flat in the key of C, of which we are told that D flat is the root. This is the chord which is frequently used in

its first inversion, which is popularly known as the chord of the Neapolitan Sixth. Now, of course, the alleged D flat root is the so-called D flat which, according to Dr. Day, is *in the key*, as the minor ninth on the tonic root; and, as we have already seen, we find it not till we arrive at the fifth octave of harmonics. Besides the extraordinary singling out of a note at such an altitude as a root in the key, when we arrive at it, it is not a true major third below our true subdominant F, and therefore it cannot be accepted as the root thereof; and when the A flat, as derived from such D flat, is added to complete this triad, both the so-called root and the fifth are at harmonic variance with the third. Yet more, in the course of my address, when speaking of Dr. Day's choice of the Tonic, the Dominant, and the Supertonic, as roots in the key, I also gave you his reason for not pursuing this system further—namely, that the last fifth, so obtained, is out of tune, and consequently unavailable as a root. How completely does he contradict himself now, in offering a minor ninth, at the high nodal point of $\frac{1}{17}$th of our stretched string, and not of the correct pitch after all, as a root in the key!

I now pass on to remark how, in marked contrast to his endeavours to account for everything, both diatonic and chromatic, in the major mode, Dr. Day has not made similarly complete endeavours in regard to the minor mode. He points out what he considers the true form of the minor scale—namely, that with the minor sixth and the major seventh, both ascending and descending, in which it is quite refreshing to say that I entirely agree with him; but he makes no attempt to establish the chief characteristic of the minor mode by deduction or otherwise. It is clear that here was a difficulty which baffled even the zeal and determination of Dr. Day, and he suffered himself to lapse into the mere statement, that the minor third on the tonic is a purely arbitrary interval, from which we are compelled to infer that the minor mode itself is simply tolerated, rather than allowed, in the system under notice.

It has been seen that Dr. Day's primary aim and problem was to derive, within the key, all chromatic notes and harmonies which could be used in connexion with that key. Up to the point I have reached, he appears rather to have sought to discover a theory which would explain and legalise common practice in this direction; but having thus, as it were, fixed his views, he thereupon proceeds to dogmatise. As I have shown you already, in regard to his subdominant triad, so he throughout considers every chord in the diatonic series as derived from one or other of his three roots in the key. Thus he holds that the *diatonic* triad on the supertonic in the major mode (D, F natural, and A, in the key of C) is part of the chord of the major ninth on the dominant G. Similarly, the triad on the submediant (A, C, and E, in the key of C major) is to be considered as part of his chord of the major thirteenth on the said dominant. And then, proceeding on this principle, he actually excludes the triad on the mediant

of the major mode (E, G, and B, in the key of C) on the ground, in his own words, '*that it appears to belong to another key—that it cannot have the tonic for its root, as the major seventh from that root is part of it*' (while, as we have seen, Dr. Day's roots give the so-called minor seventh only), and he goes on to show that, for various other reasons, it cannot be a part of any other fundamental chord in his system. The gist of all this is, that he interdicts the triad on the mediant of the major scale, simply because he cannot find, according to his views, a root for it in the key—or, rather, because it does not conform to his tonic root, according to which, as we have seen, the B natural should be the harmonic so-called B flat. This rejected triad on the major mediant is permitted to make a sort of furtive appearance only in a sequence, the symmetry of which would be destroyed by its absence; but, in its *first inversion*, it is freely permitted without let or hindrance of any kind, and Dr. Day makes no attempt to explain away his illogical teaching, that a chord which is *out of the key* in its first form is, nevertheless, *in that key* when used in its first inversion. Something prohibitory in regard to this chord is also advanced by Fétis and other theorists. To me it seems pure dogmatism. That the chord is not much used is true—the same may be said of the diminished triad on the leading-note, of the extreme triad on the mediant of the minor scale, and of some other chords; but its use or its non-use is a question for the composer—its availability is the only question for the theorist. Now, Dr. Day admits that there are instances in which the best writers (Handel especially) use it, but adds that he thinks '*always with bad effect, the chord having nothing whatever to do with the key.*' As Handel is thus singled out as a chief culprit, I will first give you extracts from some of his works, to enable you to test Dr. Day's verdict.

(*Illustrations from Handel, followed by others from Sir John Goss, Stephen Heller, and Mendelssohn, the last-named including the War March from 'Athalie,' which furnishes instances of the use of the Chord in question, not only in its first form, but also in its second inversion.*)

These, Mr. Chairman, Ladies and Gentlemen, are a few instances, called at random, of the—am I to say *bad* ?—effect of that chord which is positively forbidden by Dr. Day.

Similarly, his unyielding views respecting tonality lead him to deny the possibility of any modulation during the course of a pedal-note; and it is remarked, with an obvious aim at cogency, that the key-note and the dominant being the only notes available as pedals, if the key were changed thereon, they would then cease to be either the one or the other. It would take me a very long time to fully combat this view in words, and to show how keys in certain affinity with that represented by a pedal-note may be transiently used thereon; so I will here content myself by offering you a few well-known instances where such transient modulation *does* occur on a pedal-note, leaving you to draw your own conclusions on its prohibition by Dr. Day.

(*Illustrations, including the Tonic Pedal at the opening of Mendelssohn's Pianoforte Concerto in G minor, and the Dominant Pedal, commencing at the 21st Bar of the second part of the slow movement in Beethoven's First Symphony.*)

Among such transient modulations is that on a dominant pedal (G in the key of C major), by means of a chord with a major third on the submediant (A), proceeding to the minor triad on the supertonic (D). This is of such frequent occurrence that Dr. Day evidently felt it necessary to account for it in some way; so, still steadfast to his prohibition of modulation on a pedal-note, he here clumsily admits the submediant (A), as an exceptional root in the key, in this particular case only; and it has been urged, as a sort of further explanation, that it seems to be a consequence of the notes of the Minor Supertonic triad being all traceable to the Dominant root (which, by the way, I have shown you that they are not), that this said exceptional fundamental harmony on the submediant (elsewhere to be considered unavailable, as being out of the key) may be used on a dominant pedal, if followed by this minor supertonic triad. Even from Dr. Day's point of view, I confess I do not see the force of this reasoning, which merely amounts to saying that a fundamental chord on the submediant, which chord has no connection with the key, may yet be used, provided it is followed by another chord which is in the key. But, besides this, the said chord on the submediant, on a dominant pedal, can be eligibly followed by other chords than that particular one insisted on by Dr. Day, and thus his whole argument falls to the ground. (*Illustrations.*)

Finally, on this head, I will show you that this transient modulation, by a fundamental chord on the submediant of a major scale, can also take place even on a *Tonic* pedal, of which Dr. Day takes no cognisance whatever, and which still further frustrates the conditions he imposes.

(*Illustrations, including the Third Bar of the Allegro of Mozart's Overture 'Don Giovanni'; the Tonic Pedals in the Coda of Beethoven's Pianoforte Sonata, Op 26, and in the Coda of Mendelssohn's War March in 'Athalie.'*)

And so, in this matter, Dr. Day has again dogmatised, and not only so, but, in this instance, he has done it in direct opposition to himself. You will remember that, when speaking of his selections of the Tonic (C), Dominant (G), and Supertonic (D) as roots in the key, I told you he said we could not carry the system further—*i.e.*, adopt the last obtained fifth (A) as a root in the key, because it is a little too sharp. Yet here, at last, he has himself admitted this very note in that capacity, involving, moreover, the enharmonic diesis between its major third (C sharp) and the minor ninth (D flat) on its tonic root, on the strength of which, alone, one or other must, according to his own arguments elsewhere, be out of the key.

There are other points in connexion with Dr. Day's views, my objections to which would be merely a recapitulation of what I have said in other cases, so I pass on, lastly, to make one solitery appeal to auricular sense and innate conviction. Straws, it is said, show which way the wind blows, and true it is that small matters are frequently conclusive tests of important ones. In Music, besides our notes of harmony, we have what are called discords of transition, comprising passing notes, auxiliary notes, &c. Here, on my diagram, you will first see a short chromatic passage in the key of C, with the notation ordinarily employed (C, C sharp, D, D sharp, E). Here you will see the same passage, with Dr. Day's notation (C, D flat, D, E flat, E), according to his derivation of those notes and the chords with which I will presently accompany them. The mere materialist might say, 'What does it matter whether you write C sharp or D flat, D sharp or E flat, in such cases, especially in music for the organ or the pianoforte, where the sounds are identical?' True, in one sense, though this is not argument; but, in ornamenting these notes of harmony, for experiment, with the auxiliary notes above them, the result differs very materially, according to which notation you adopt. Thus, the auxiliary note above C sharp is D; but if you write D flat instead of C sharp, the auxiliary note above is then an E. Similarly, if you write D sharp, the auxiliary note above is E; but if you write E flat instead of D sharp, the auxiliary note above is then F; and so the passage is dissimilar in actual sounds in the two cases. I will now play the two passages, with harmony—first, in accordance with the usual notation:—

Illustration.

and, secondly, according to that of Dr. Day:—

Illustration.

I could indefinitely prolong such tests, but it is needless; and with this solitary appeal to innate conviction, and without one further word of comment, leaving the verdict to yourselves, thus end, for the present, my remarks on Dr. Day's 'Theory of Harmony.'

I now proceed to speak, very briefly, of the elements of a new

system, to which a very careful and lengthened study of the subject has led me. At the very outset, I adopt the views of the older theorists, but it is in the extension of the system, to embrace the whole range of harmony, diatonic and chromatic, that its speciality consists. I first assume, as a *central* point, my key-note only; and then everything is added, by deduction, &c., in the direction pointed out by natural facts, and invariably in conformity therewith. Beyond the key-note, I view every note which can, in the way I will show, be taken as a root, as a *remove* from that key-note, and consequently only in a certain degree of affinity with it—my system thus resembling, in some degree, those to which the name of Omnitonic has been given. From each of my roots I deduce *two* harmonics of another name *only*, the two such harmonics which arise earliest in the illimitable series, and which experience has proved to be the chief and most important. You are all, doubtless, aware of the illimitability of harmonics, that only a selection from them can possibly be included in any musical system, and that the desideratum is to know where to leave off. I do so at that note which presents the first barrier—the harmonic minor seventh, about which I have already said so much, and I adopt only the third and fifth (and, of course, their octaves and that of my root). This process, taking my key-note, C, as a root, gives me E and G. I then take, as a new root, that note which stands in what I term the first degree of affinity with C—namely, its first harmonic of another name, G; and this G, as a root, gives me B and D. What then is to be done to increase our resources? Pursue the same system of affinity, but look backward as well as forward; and as I took G as the first new product of C, so I now take, on the other side, that note of which C itself is the product, and so I surround my key-note with its nearest relatives. That note is F, the true and honest subdominant, and properly so named, as being one of the governing powers in connexion with the key, and under the key-note in its true harmonic position; and this F gives me, as its third and fifth, A and C. You will thus further recognise the appropriateness of the otherwise unmeaning term of *submediant*, as applied to the sixth note of the scale. As I have shown you, the true subdominant F is, in harmonic position, below the tonic, and the A thence derived is the *midway* note between the two, and hence its name, *submediant*.

In my diagram you will perceive, first, my subdominant root and its adopted products. I have carried these up beyond their first completion, for a reason which will immediately become obvious. Then come the key-note (at its true harmonic distance of the twelfth from the subdominant root) and its adopted products, carried up also sufficiently high for my purpose; and, lastly, my dominant root (also at its true harmonic distance of the twelfth from the key-note) and its adopted products; and then, immediately, the major diatonic scale, with its exact order of tones and semitones, is supplied by my three roots, which are

linked together, as you have seen, by nature, thus showing that that scale is no arbitrary invention or assumption by man, no mere bubble of fashion, no creature of the hour—but an actual suggestion of nature, primeval with creation itself

You will next see these notes arranged in close harmonic order, commencing with the subdominant, followed by the key-note, and then by the dominant, each with its adopted products; and after the last of these, we simply resume the original series, temporarily displaced by the others, and we go on again.

My theory then is, that these various roots and their adopted products, standing in certain degrees of affinity with each other, can be heard in combination—according, of course, to certain principles; and we thus have, up to this point, the whole range of what is termed diatonic harmony before us Diatonic triads, diatonic chords of the seventh, ninth, eleventh, and thirteenth are all here. Take, for instance, the diatonic chord of the eleventh on the subdominant. It includes the subdominant and the tonic triads, and part of that on the dominant This chord is, of course, not explained by Dr. Day's system, as it has a major seventh and an extreme eleventh

Extending my system further, I next arrive at my roots in a *second* degree of affinity with my tonic or central note—namely, D above, and B flat below. The former gives me, as its adopted harmonics, F sharp and another A; the latter is the parent of F, as F was of C, and gives me also another D Then also, by a natural process of affinity—which, with many other points, I must not now stop to explain—I arrive at that grand desideratum, the minor thirds from my roots, which furnish me with the true diatonic series in the minor mode, and it is important to remark that this natural process gives me the key-note and the subdominant triads *minor*, but the dominant triad *major*, thus establishing the true minor scale, with the sixth minor and the seventh major. I also thus find my chromatic scale, or rather one of the forms thereof, and while no other system with which I am acquainted furnishes a radical harmony to the chromatic scale, mine does so, and every note can be accompanied by the triad of which it forms a part according to the roots I have indicated—this being, perhaps, some evidence of the soundness of my derivations (*Illustration.*)

The keys and chords in affinity with my tonic I call cognates of that key, and, in the case of C major, they include, besides what I have already shown, D minor, E minor, and A minor, the dominants of which furnish me also with C sharp, D sharp, and G sharp, and give me another form of the chromatic scale in connexion with my primary key This form of the chromatic scale can equally be accompanied in a similar manner by the true basses, with triads only, but as in this case the bass progression occurs twice in the chromatic scale itself (E, F, and A, B flat), the use of that progression also in the bass, with triads, involves two dreadful instances of consecutive fifths and octaves. If you

will overlook this incident in consideration of the real point at issue, you will fully realise what I mean by the natural bass to this, my second form of the chromatic scale in connexion with C major. (*Illustration.*)

Lastly, for the present, my two A's, two D's, &c., being, as you know, by their derivation, of different pitch, and it being indispensable to limit our system and establish a cycle of keys, temperament here comes to my aid. It would be shallow to rebuke me here, and accuse me of ungenerosity to Dr Day in respect of his three E's of different pitch, in not suggesting that temperament would remove the difficulty in his case also Dr. Day's three E's are derived by himself from what he claims as roots in the key, which is untenable when we find their results at variance with each other But my two D's, two A's, &c., are derived from roots only more or less *in affinity* with my key-note, their origin being a *remove* therefrom; and so I claim temperament to reconcile little family jars between the more distant branches. I then show how, the family feuds healed, some of the extreme branches may, under certain conditions, amicably commingle; and we thus not only arrive at the whole range of ordinary chromatic harmony, but we have also available, and legalised, such chords as that at the beginning of Haydn's Chaos, consisting of B, D, A flat, and F sharp, and I also obtain a variety of combinations and treatments, some of which I have never yet met with in musical compositions, and others that are, to say the least, rare. (*Illustrations.*)

I have thus very briefly laid before you a bare outline of a new system. I do not invite discussion on this part of my address, as I have necessarily treated it in a very cursory manner But, reserving to myself the right of reply, I shall be pleased if any champion of the Day theory will break a friendly lance with me, only let him not say merely that it is expedient, or convenient, to accept Dr. Day's false derivations as true Dr Day professes to obtain these from roots in the key, and we have a right to require that they be what he asserts them to be—otherwise those deductions are false and untenable. If convenience and expediency instead of truth be all that is aimed at, then away with science, and assume all, and try not to make that appear scientific and philosophical which has no claim to such distinction.

DISCUSSION.

The CHAIRMAN, after expressing the thanks of the Association to Mr Stephens for his paper, called on Mr. Ellis to give his promised illustrations.

Mr. ALEXANDER J. ELLIS, F.R.S., said that his object was to make some of the chords proposed by Dr. Day audible, because it is not possible to judge of the effects of such systems of harmony as that advanced by Dr. Day, which were dependent on peculiar intonation, by means of instruments tuned, as the pianoforte, in equal temperament. He was not able to exhibit all of Dr. Day's chords, but he could show some of the most important. So far as he had hitherto been able to discover, systems of harmony, before Dr. Day's, were of four kinds: *Octaval* (founded on the octave only, as in equally-tempered instruments, which have of course no other interval strictly in tune); *Quintal* (founded on the octave and fifth, including of course the fourth, the defect of the last from an octave, and the extensions of these three intervals by an octave, forming the only six consonances recognised by Greek writers on Music, to whom the thirds, which Mr. Ellis played, were necessarily dissonant); *Tertian* (founded on the octave, fifth, and major third, including the fourth as before, and the minor third as the defect of a major third from a fifth, and the sixths as defects of the thirds from an octave, with the extensions of all these intervals, and hence comprising all the consonances generally admitted in modern music); and, finally, *Septimal* (including all tertian, and also the results of introducing the harmonic or subminor seventh). Mr. Poole, in Silliman's 'American Journal of Science and Arts' (Vol. 44, July 1867), describes an organ with 100 pipes to the octave, in which 39 of these septimal tones are introduced to play the dominant seventh in all major and relative minor keys. Mr. Ellis's instrument, which was none other but Sir Charles Wheatstone's symphonion, had been tuned for the purpose of exhibiting the effects of the septimal chords employed by Mr. Poole, and it served also to show the effect of the most characteristic chords of Dr. Day's system. Mr. Ellis then proceeded, by means of this instrument, to exhibit the effect of the chord C, E, G, subflat B (the septimal note), D (of the key of C, sharper by one comma than D in the key of F, the nonal tone), and to compare it in all its parts and inversions with the chord of C, E, G, flat B (in the key of F, being the true fifth below it), D (of the key of F), and showed especially the superiority of C, E, G, subflat B, to C, E, G, flat B, in all inversions, and also the superiority of E, G, subflat B, to E, G, flat B, in all inversions. Then he showed that G, subflat B, nonal D (of the key of C) gave a peculiar minor chord, not much inferior to the true minor, whereas G, flat B (of the key of F), and D (of the key of F) produced a strong dissonance. He further illustrated the effects by playing '*Leise, leise*' from '*Der Freischutz*,' in F—first as a melody with subflat B, and then harmonised by means of the above peculiar chords, so as to show their effect. Finally, Mr. Ellis stated his belief that the advantage in a few chords derived from using the septimal tones was not sufficient to compensate for their theore-

tical difficulties (on which he forbore to enter), and that nothing but noise would result from using the harmonic eleventh, thirteenth, and seventeenth, reduced to the usual octaves, as proposed apparently in Dr. Day's system

The CHAIRMAN having stated that it was now time to close the meeting, it was decided to adjourn the discussion till four o'clock at the next meeting, and to close it at five o'clock, in order that Mr. Hullah's paper might come on at the usual time.

ADJOURNED DISCUSSION

MONDAY, MARCH 1, 1875.

WILLIAM POLE, ESQ., MUS. DOC. OXON, F.R.S., occupied the chair.

Dr. W. H. STONE, M.A., acted as secretary, in the absence, from indisposition, of the Hon. Secretary, Mr. Charles K. Salaman.

Mr. WILLIAM CHAPPELL said there was one point in Mr. Stephens's paper on which he had to comment—viz., where Mr. Stephens (according to the report in the 'Academy') spoke of the high order of harmonics, and said: 'To produce even those approximate representations, it was necessary to take harmonics so high, that they have no real existence as musical notes. Thus the twenty-fifth harmonic is employed.' . . . . 'A similar derivation of the minor third from the nineteenth harmonic is given in a well-known modern work on Harmony.' What he wished to observe was that the twenty-fifth harmonic was employed, and necessarily employed, because if we want semitones at all, we must begin with 17, and go up to 31 in the octave; in fact, there is no possibility of getting a semitone from the root, or fundamental note of any scales, if you take less than 17. 17 is the C♯, in the scale of C, and 19 is D♯. It makes no difference whatever in the scale, whether it be taken from 16 to 32, or from 8 to 16—because 16 is the same note as 8, only an octave higher. The ratio of 16 to 8 is the same as 2 to 1. A true octave scale of tones and semitones must be from the sixteenth to the thirty-second part of a string—the even numbers being the tones, and the odd numbers the semitones.

There was one part of this report which he did not understand, and thought it must be a misprint, where it said that the only harmonics Mr. Stephens admits are the twelfth and the tierce; under the conviction that it is a mistake of the reporter, he refrained from comment.

As some of the members did not absolutely know what the

harmonic scale was, he thought it desirable that they should hear it; and, therefore, he went to Sir Charles Wheatstone, recollecting that in one of his early lectures, perhaps some fifty years ago, he had exhibited this instrument, on which he produced all the harmonic intervals. At that date harmonium or Eoline springs had not been invented, and he therefore placed a common jew's-harp at the end of the tube. It is very deficient in power, but still, with perfect silence in the room, the notes are audible. He was sorry to say that the tube or the piston which works in it was not quite perfect, and the sound was therefore very feeble; but on agitating the tongue of the jew's-harp, and then moving the piston up or down the tube, the different intervals are easily distinguishable—by those, at any rate, who are near it. It produces a perfect two-octave harmonic scale from C, both in ascending and in descending order.* There is a slide by which it can be adjusted. If it is put at half the length of the tube the octave sounds, and in the same way every one of the harmonics in this harmonic scale, taken from his 'History of Music,' could be obtained. He would say that the numbers prefixed to the sounds were the most essential things in the scale—much more important than the numbers of vibrations, which are difficult to count. If any one learns these numbers by heart, he knows the ratios of all intervals; the 9 is the ninth of the string or pipe, the 10 is the tenth, and so on. He would further add that Mr Stephens's own plan seemed a very sound and practical one. This tube showed that from the C you could get all the 16 tones and semitones from C; they come directly from it, but you can sound no F, no B♭, and of course no A, because our A is out of tune in the scale, it is tuned as a minor tone, when it ought to be a major, in nature. Therefore, so far as Mr. Stephens's paper was concerned, he thought the system he proposed was perfectly just in science. He did not profess to give opinions in practical music, but in science he thought it a perfectly just and true system.

Mr. Banister said, that although he had not thoroughly gone into the question with regard to the mathematical points, yet he was exceedingly pleased, not only with the views enunciated by Mr Stephens, but with a brief conversation he had with him some months previously, when he went over the theory with regard to harmony in a way which seemed to him exceedingly clear. He was quite fascinated with the theory—so much so, that in case of another edition being called for of a little work he had published some time ago, he should be pleased to give an epitome of Mr Stephens's theory, it seemed so exceedingly clear and able.

* The instrument employed was a tube-like part of an organ pipe, of about two feet long, fitted with a piston, and having a jew's harp, tuned to *c*, fixed to the open end of the tube. From this one *c*, every note of a true scale was produced with great rapidity, by drawing the piston up and down. [Mr Chappell has since fitted up a tube with a harmonium spring instead of a jew's harp, thus making the scale audible in any room.]

Mr. Alexander John Ellis, F.R.S., said that with regard to Dr. Day's theory, he had attempted at the last meeting to make those present hear the effect of the chord of the major ninth with the harmonic seventh in the chord of C,—thus, C, E, G, the harmonic B♭, and the D which was the perfect fifth to G—and to show that that was really superior to the ordinary chord where the B♭ was got from the subdominant. But he wished to ask the question whether Dr. Day's system had ever been tried upon instruments with sustained tones tuned to it. He did not know how the 11th and the 13th were tuned—whether they were the 11th and 13th in the scale, or whether they were the harmonic 11th and 13th, or in what way they were produced; and he wished to know whether those gentlemen who adopted Dr. Day's system had really tried it in practice, or whether it was not to them merely a paper theory, which the equal temperament would represent as well as any other paper theory.

Mr. Charles E. Stephens said that, from his conversations with some partisans of this theory, it seemed to him they adopted a purely paper view of the question. When he said that no perfect fourth existed from the root, and consequently those chords, called chords of the 11th, were not existent in nature, then refuge was taken immediately in the assertion that we ought to adopt the F nature gives us, not the F we require as our subdominant F. Mr. Ellis's suggestion that these chords should be tried, tuned according to these natural principles, ought to be placed before the Association on some occasion, when they would be able to judge of the effect for themselves. He felt that we must have a finite system in music, and therefore we must discard those intervals which warred with nearly every other. The harmonic minor seventh, as Mr. Ellis showed on the last occasion, would thus be seen to be not available for musical purposes, and, as he showed us, chords in which it is comprised were simply hideous. They give us a major third which is considerably beyond a major third; in fact, they war so with our musical system generally that they must be discarded. When he endeavoured to pin an adherent of Dr. Day's system to the circumstance of there being no less than three separate pitches in that system for one particular note of the scale, that is, the major third, he replied, 'Yes, it is true; but if voices were not vitiated by practising so on our limited system, we should perform those chords truly, and should feel them in tune.' They would sing one pitch to E, if you spoke of the Triad; another pitch if you talked of the Dominant, calling it in that case the major sixth, and another pitch, again, if you took the Supertonic as the root. It was, therefore, maintained even to that extent by lovers of that theory—that they would change the pitch of a note in accordance with the note of the chord with which it is accompanied.

Mr. James Higgs, Mus. Bac. Oxon, said that there was a real difficulty connected with the subject which had not been met, or

in any way alluded to. Any theory of harmony might be said to have for its object to set forth the rules which regulate the combination and progression of notes used by musical composers. The objections Mr. Stephens had made to Dr. Day's theory had been to a great extent based upon the fact that certain of the harmonies are not identical with the sounds the musician employs. But Mr. Stephens's theory of adjacent triads seemed to be open to precisely the same objection. He (Mr. Higgs) ventured to believe that composers have always had fixed-toned instruments in their minds, and that they have always written in equal temperament. If that be so, the thirds and fifths, upon which Mr. Stephens's system is founded, deviate from the practical musician's notes just as do Dr. Day's higher harmonics. He thought it easy to show that composers have always written in equal temperament, for on any other supposition—if we take any simple composition by Haydn, for example—we find, as soon as he moves out of his original key (let us suppose C major) into the key of the dominant, he will use notes as the harmonics of the original supertonic, which either are not identical with the notes of the original scale, or are not in tune in the new key. But he (Mr. Higgs) declined to believe that Haydn intended different sounds for the A and C, according to whether these notes represented the sixth and octave tonic of the original key, or the fifth and seventh of the supertonic as the dominant of the new key. He knew it was sometimes asserted that string-players did make these distinctions. He was not a string-player, and was therefore not competent to speak in any practical way upon that point; but he would judge of this paper theory by paper-work. In one of Beethoven's later quartettes, in F, there is a slow movement in D♭: it closes in D♭ major, and instantly the violoncello, which has been on D♭, takes C♯ for the *Intermezzo*, which is in C♯ minor. Now, he considered it was never intended by Beethoven that the sound should waver up or down. Practical musicians would say one thing, and mathematicians would say another, but he believed Beethoven intended that the same sound should be produced. What is wanted of a system of harmony is to deal with the tones that composers use, and such a system he believed Dr. Day's to be. He held that the beautiful power of the human ear, which Mr. George Macfarren so eloquently alludes to in more places than one, fully explained the whole mystery—a power which he claims for the ear of being able to hear, not the sound actually sounded, but the sound that should be sounded. In that way, and in that way alone, could the thirds and fifths derived from the adjacent system be reconciled with the notes that practical musicians have ever used; and by such a means he believed all the discrepancies of Dr. Day's theory might be simply explained. He by no means pretended to understand the whole of Dr. Day's theory, but the more he had been enabled to look into it, the more his opinions had gradually come round to the belief that the theory did give

a system of harmony of the highest practical value to musicians. He believed the essential point to be this, that composers had always written in equal temperament, and that equally-tempered instruments were best calculated to interpret their compositions. Much of the art of musical composition consisted in the ambiguity of a note—taking a note as belonging to one key, and leaving it as belonging to another, and that could only be effected by thinking of some one note, not of two or three.

Mr. CHARLES E. STEPHENS replied that Mr. James Higgs's remarks pointed to the very great importance of temperament—because without temperament we should cease to have music altogether. And his remarks about the change of the D♭ into C♯ were quite pertinent; it is absolutely certain that Beethoven intended no change of pitch to take place on that note. But the question of Dr. Day's theory, or any other theory, did not affect that question in the slightest degree. All must come to this, that we eventually make a cycle of keys, and returning to D♭ we consider it the same as C♯. But his system did not present the same contradiction that Dr. Day's did; it did not give two or three pitches for the same note, as deduced from different roots in the key. Dr. Day's system, on the contrary, supplied more than one pitch for the same note in the key, and consequently he maintained that such a system could not be tenable—that it was a contradiction in itself. Whatever number of notes might be necessary to make a perfect scale available in all combinations, one thing certain was, that the major third in the key of C did not admit of being treated in three different pitches, according to the three different chords in the key you accompanied it with.

The CHAIRMAN stated that, after a great deal of study of the subject, he was a little inclined to be what Mr. Stephens called an unbeliever. He had some doubt whether any theories, in the sense that they are now spoken of, were sufficient for the purpose, and he was not in bad company in holding that opinion. The first unbeliever of note was, as Mr. Stephens said, admitted on all hands to be a very eminent theorist in Germany, and one whom Germans have always held in great reverence—namely, Gottfried Weber. He was certainly an unbeliever in the same sense—that is, he was of opinion that no *à priori* theories of harmony were sufficient to account for the facts observed. That was many years ago, but there had lately been another corroboration of the same idea, in an excellent article, only just published in the last number of a large and elaborate Dictionary on Music, now appearing in Germany, the 'Deutsches Musikalisches Conversations Lexicon.' It was written with great care, and evidently great knowledge, by Otto Thiersch, on the subject of Harmony. He found the author of this was also to a large extent an unbeliever, like himself. He gives a minute account of almost all known theories of harmony. Although there had been some deep thinkers and writers on Harmony in England, those in Germany had been ten times as many; the Germans were very highly educated in music,

and theories of harmony broached and published in Germany were legion. The writer of this article gives an analysis of them, pointing out what he considers the good and bad points of each. He had copied out one sentence at the end: 'Thus all these systems of harmony either rest on untenable assumptions, or are wanting in practical consistency; and they are altogether insufficient to explain even the works of the acknowledged classical masters, to say nothing of the way in which they so commonly attribute monstrosities and errors to the compositions of the more modern school.' In the course of his remarks he mentions the opinion of Weber, and gives a very good account of his doctrine in one sentence. Weber was a man who, although a great theorist, conceived that, in treating harmony, we should view it in a practical light, and the writer of this article gives this sentence as the sum and substance of Weber's doctrine: 'Weber only seeks to make the pupil acquainted with the chords that are used in music, and does not attempt to explain them, or give their derivation.' Then he gives a long account of Helmholtz's views, not his acoustical theory, but his remarks on Harmony, musically considered, which had not yet been published in England. However, Helmholtz, although he does a great deal to deduce chords and harmonic progressions by theoretical rule, appears by no means confident of the sufficiency of the explanation, and he is a man who, if theory were competent to explain all those things, ought to be able to do it. He says—quoting from Otto Tiersch: 'The system of scales and modes, and all the network of harmony founded thereon, do not seem to rest on any immutable laws of nature. They are due to æsthetical principles, which are constantly subject to change, according to the progressive development of knowledge and taste.' That, of course, is the same thing as saying that no *à priori* theory of harmony can be constructed which is sufficient, because, if harmony depends only on æsthetics and taste, it cannot depend on physical natural laws. Then again he says: 'Helmholtz is quite aware that pure physical and physiological principles will not suffice for the explanation and derivation of musical rules.' There was no time now to go into the subject at length, but it was remarkable what a number of theories had been made, and also what immense contradictions they involved with each other. No better instance of this could be brought forward than that of Dr. Day. It had, however, recommended itself to eminent men, amongst others to Mr. George Alexander Macfarren, who spoke highly of it; and also to some extent to the Rev. Sir Frederick Gore Ouseley, who, however, did not entirely agree with it. Now we were shown grounds why the theory is insufficient, and in some cases bad; but such objections, he believed, might be raised to almost any theory that attempted to go to the origin of things. He was inclined to think, with Weber, that systems of harmony would be much better if they, like many books of harmony, were confined to statements of facts. We find

certain things done by eminent men, and the most useful course is to state clearly what they consist in; the chords and progressions of which they are composed might be classified and explained. He did not think that we are, at the present, able to say, as some elaborate systems do, that because of certain laws of nature, such and such things are right, and such and such things are wrong. To assert that there are laws which shall regulate what kind of musical composition is good, and what kind of musical composition is bad, was, he thought, going on the wrong tack; it had proved so over and over again, because, if we were to go back, and see what people thought of musical theory years ago, we should find that, as knowledge and music advanced, old rules were upset by later views of composers, which were instantly conceded by the hearers. To form rules which would be set aside by exceptions, and at last totally subverted as music advanced, seemed like beginning at the wrong end. There was more than one analogy for this view. Take the case of language. If anybody were to set to work to show why, on natural principles, it is proper that verbs and nouns should take particular forms, it would be very foolish and inconsistent, but that does not do away with the necessity for grammar. We find certain rules established by the best authors and speakers, and we tell pupils that such and such things are right, being sanctioned by the best authorities. Again, take botany. If anybody were to say that, in the nature of things, a plant should grow of a particular shape, or a flower of a particular colour, he would evidently be going beyond common-sense and reason; but that does not get rid of the necessity for the classification of botanical facts, which may be laid before the student, in order to furnish an easy method of giving him knowledge. Following out that idea, so long as systems of harmony are statements of what may be called musical facts—that is, explanations of what has been done by the best writers, and what has been found to be pleasing to the hearers,—and so long as they lay down rules of that kind as examples for the student to follow, they will be good, and will be incontrovertible, because they do not touch on this forbidden ground. But he could not help thinking that to go deeper, and to attempt to explain all music, and all the infinite complications of musical composition, upon theoretical, physiological, physical, or mechanical principles, is to go to an extent which is not only unnecessary but untenable, and calculated to lead the student into the supposition that he is to act upon unknown mathematical views, instead of what he ought to be guided by—the practice of the best composers.

MR. CHARLES E. STEPHENS remarked that what the Chairman had said about the observance of the practice of the old masters was of course most important and judicious, but he maintained that the facts of harmony are supplied by Nature herself, and he grounded some of his objections to Dr. Day's theory on that principle. Nature might have chosen that two notes of different

pitch should never be consonant with each other; but she has chosen that certain notes bearing a certain ratio to one another shall be consonant, and consequently it is incontrovertible that Nature herself has given you at least the foundation for harmony. To discard this, and rest everything on what this person has done, or on what sounds well, is certainly not the view that teachers of our art ought to take, because it is their duty to make themselves masters of the truths of science, in order that they may lead their pupils aright.

MARCH 1, 1875.

DR. WILLIAM POLE, F.R.S., IN THE CHAIR

ON MUSICAL NOMENCLATURE.

By JOHN HULLAH, Esq.

I PROPOSE in this address to deal with certain names or terms and epithets in use among English musicians. Many of these, it is certain, have outlived the ideas or things for which they once stood; others now represent to all of us ideas and things different from those they once represented. The time seems to have arrived when we should come to an understanding as to our musical nomenclature. It will not, I think, be found necessary to make any addition to it; at any rate, I have none to propose to you to-day. But I shall simply ask you to consider and, if possible, to decide, which out of many names or terms representing, and epithets qualifying, the same thing, it is desirable to adopt or recommend for adoption. Musical nomenclature has reference, of necessity, to time, to tune, and to expression. I will deal with its application to these separately. Under the head of time, let us first consider the duration names of musical notes. Those which at present concern us are—breve, semibreve, minim, crotchet, quaver, semiquaver, and demisemiquaver. Of these names, the first three have altogether lost their significance; the fourth is no longer appropriate; the fifth, sixth, and seventh are arbitrary. The breve is no longer short, but unusually long; the minim is not now the least or shortest note, but not unfrequently the greatest or longest; the crotchet has now no crotch or hook, and the quaver and its fractions might just as well be called the 'shiver,' the 'half-shiver,' and the 'quarter-shiver,' or by any other names as fantastic or irrelative. The Germans call these notes, beginning from our semibreve, the whole note, the half note, the quarter note, and so on. These appellations, so far as they express the proportion of the first note named to those which follow it, are convenient. They form themselves a time-table, but it is an imperfect one, for they do not show, without further calculation, any intermediate proportions. They show at once that eight quavers equal one semibreve, but not at once that four quavers equal one minim. But I have a much more serious charge to bring against them. They assume what, if not always false, is, as it seems to me, not always true—that the semibreve is, or that any form of note can be, absolutely a whole note. What is or what should be regarded

as a whole note? If I were sure that the word 'phrase' represented to all of us the same idea as it does to me, I should answer, unhesitatingly, that a whole note was any note that could be divided into a phrase. Perhaps, however, a better definition would be, any note, divided or undivided, which would fill either an entire measure, or require as many beats as would make one. This would give us, practically, four claimants to the title of whole note: the breve, the average whole note of the 16th century; the semibreve, the average whole note of our own time; the minim, and even the crotchet. For that movements innumerable of four times or beats in a measure, each of which is a quaver, exist, I need not say, nor that the measure even of four semiquavers has been occasionally employed. It is certain that a sound lasting four beats may be expressed, and has been expressed, by six different forms—the maxim, the long, the breve, the semibreve, the minim, and the crotchet. Perhaps some musician of the future may think proper to express such a note by a quaver. Let us now consider the names used by the French, a people possessing in high perfection the power of clear exposition of what they themselves see clearly. As usual, they leave or throw on one side whatever they regard as uncertain or equivocal, or not commonly accepted, and proceed to deal with the undisputed and indisputable facts or portions of facts before them. And what are these, in respect to the forms which express the relative durations of sounds? First, that they are forms; and secondly, that they are different forms—that one is an oval or circle, that another is a circle with a stem, and another a circular spot, also with a stem; and that all other notes are opaque, and have not only stems, but hooks varying in number. They call these notes or forms—as they find them—round, white, black, hooked, twice hooked, and thrice hooked. I certainly prefer the German nomenclature, which, though raised on a false basis, is consistent, to our own, which is inconsistent as well as false; but I prefer the French to the German, because, not pretending to do so much, it does what it pretends to do perfectly. On the pitch names of notes—A, B, Do, Re, or what not—I do not propose to speak to-day. Perhaps on some future occasion you will allow me to bring some considerations about them before you. I pass on at once to another matter relating to the second division of our subject, tune—the nomenclature not of sounds, but of the relations between them—the nomenclature of musical intervals, on which English theorists and practitioners are by no means agreed. I believe that the seconds and thirds and their inversions, the sevenths and sixths, found in the so-called 'natural' scale, and all scales made like it, are very generally called among us major and minor; and that six of the fourths, and their inversions, the fifths, are as generally called perfect. Here, however, agreement ends. For the one exceptional fourth and the one exceptional fifth rejoice each in as many *aliases* as a swindler finally run down by the detective police. To the exceptional

fourth—which, according to the old theorists, 'diabolus est'—I have heard and seen applied the name 'tritone,' and the epithets sharp, superfluous, redundant, and augmented; to the exceptional fifth the epithets flat, false, imperfect, diminished, and equivocal. Others might possibly be added to this list. To the name 'tritone' no objection is, I think, open. It expresses the contents of the interval—three tones, but it carries with it the disadvantage of there being no corresponding name for its inversion, the exceptional fifth. Augmented and diminished are no doubt antonyms, but both are epithets which, as I shall try to show, ought to be reserved exclusively for another class of intervals—the chromatic. Superfluous and redundant are, I think, clumsy epithets; but if either is to be applied to the exceptional fourth, its antonym scanty, or insufficient, should be applied to the exceptional fifth. If this last interval is to be called false, its inversion (the tritone) should be called true. Only one of these epithets seem to me quite unobjectionable—imperfect, as applied to the exceptional fifth. As an antonym to this I have long used the epithet pluperfect, which has been very largely adopted. I objected just now to the epithets augmented and diminished as applied to these particular intervals, the exceptional fourth and fifth. I think these should be reserved exclusively for chromatic intervals. I know, of course, that my objection involves a principle, or rather begs a question,—What is a chromatic interval? This question, as often happens, throws us back on another,—What is a chromatic scale? A chromatic scale I should define, with Dr. Crotch, to be a scale containing more than two semitones. The so-called 'natural' scale, and all other scales made like it, is not a chromatic scale, neither are any of the ancient scales formed from the arrangement of the same series of sounds in a different order. Of these last the 'natural' minor scale is one, and the only one familiar to the modern musician. Only, however, by means of a most serious alteration has it been reconciled to modern tonality, which, above all things, demands, as the unequivocal sign, seal, or confirmation of a key, the combination known as the 'discord of the dominant seventh.' Such a combination on the fifth of the natural minor scale is only possible by an alteration or nonnaturalisation, which at once brings it under Dr. Crotch's definition. In the series A, B, C, D, E, F natural, G sharp, and A we find three semitones, and one interval greater than a tone. Moreover, by skips from one note to another of a scale so constituted, we get three other intervals alien to the natural scale,—the inversion of the altered second formed by F—G sharp, and the altered fifth formed by C—G sharp, and its inversion. These intervals are, I conceive, augmentations or diminutions of intervals which would have remained unaltered but for the artificial process needed to reconcile the minor key with modern tonality; they are therefore, I believe, generally called augmented and diminished accordingly. So all intervals which the cultivated ear does not reject as cacophonous,

formed by notes one or both of which are foreign to the key to which they are introduced, are but augmentations or diminutions of those that are natural to it. Without change of key we can augment certain of the unisons, seconds, fifths, and sixths, and diminish certain of the octaves, sevenths, fourths, and thirds. Now, as we have seen, in the unaltered or natural scale, major or minor, we find no examples of any one of these intervals; they are uniformly the result of artificial treatment. But with the exceptional fourth and fifth the case is altogether different. They are not the results of artificial treatment—we find them ready to our hands; and they are as much constituent parts of the scale in which we find them, as is the semitone between the third and fourth sounds. How, then, can the interval F—B, in the scale of C, be augmented, or B—F diminished? Of what are they augmentations or diminutions? Of F—B flat, or of F sharp —B? Are B flat or F sharp constituents of the scale—I do not say the key—of C? If they are, our modern tonality must be reconstructed *de fond en comble*, and every scale must be allowed three dominants instead of one. Again, we find that the intervals of the natural scale which hear augmentation are the largest of their kind in it, and those which will hear diminution the smallest Of the seconds we can augment only the major, of the thirds we can diminish only the minor. Can we augment the tritone, the largest fourth in the scale, or diminish its inversion, the smallest fifth? Both have reached their utmost limits, and resist and defy all attempts to put them farther asunder, or bring them nearer together. If it be answered that they are already augmented and diminished, I ask again, what was their original condition? The tritone and its inversion are, I repeat, constituents of the diatonic scale; and they are diatonic intervals accordingly. For the latter an epithet, imperfect, is already largely accepted I submit to you, in the absence of a better, the epithet pluperfect for its inversion. Before quitting this second division of my subject—pitch—I will ask you to give me your attention for a few moments longer. It seems to me, that musicians have much cause to complain of the way in which not merely general litterateurs but even scientific writers employ words to which, since music has been an art, musical artists have agreed in attaching certain definite significations. Perhaps the most glaring instance of this, and it is only one which I shall give, is the employment of the word 'tone' to express the thing or sensation which we and they also sometimes call 'sound.' A tone with us is not a sound, hut the relation or difference between one sound and another. This acceptation of the word would seem to be, if not as old as the musical art itself, at least of great antiquity, as is shown in the coexistence of two such words as tetrachord and tritone—the one, of course, representing a passage of four sounds, or strings which produce them; the other an interval which, though it includes four sounds, is named after the three intervals—tones—which separate them. We hear now of

overtones, or the acute sounds resulting from spontaneous vibration, and of undertones, meaning grave sounds resulting from the combination of others. Some of us have occasionally been at a good deal of pains to explain that a major third consists of, or includes, two tones; if a tone he sound, a major third must consist of three, or even of five tones, or of both three and five. The most recent and extravagant employment of this word, in this sense, is in its application to great composers. Beethoven, especially, we often hear of as a great 'tone poet.' I should say that if this terminology is to be accepted at all, it should be graduated or made more precise, so as to express the rank of the poet to whom it is applied. If Beethoven be a tone poet, some of our contemporaries should be authorised to call J. S. Bach an 'augmented tone poet,' and, *e converso*, Rossini a 'semitone poet.' What designation should be applied to the vast crowd of less successful aspirants to musical fame I know not. Perhaps they might be put off with some of those minute intervals, the excess or insufficiency of which disturbs the minds of those who still generously devote themselves to the search after that 'philosopher's stone' of our art—perfect intonation. I pass on now to the consideration of expression, under which term we may class words and songs indicative of pace, intensity, and style. A growing disposition has been observable of late among the different musical people of Europe to use their own languages as vehicles for these indications I think this is to be regretted—(1) as inconvenient to foreigners among whom their music is likely to go. It seems hard on an English, French, Italian, Hungarian, or Bohemian musician that, to understand a piece of music by any eminent modern German master, he must not only be a musician, but a linguist; that he should not merely be able to appreciate the musical sound of the notes in the score before him, but have also a vocabulary—practically unlimited—of German words He opens, say, Schumann's overture to 'Genovera.' He sees, by the position of the stave headed by the C clef, and designated 'Bratsche,' what is the meaning of that word; he need not have much doubt about the stave similarly headed, and holding three parts, against which is written 'Posaunen'; by the shapes of the passages intended for them he may construe 'Ventilhorn in Es,' 'Waldhorn,' and 'Pauken,' and by the help of the metronome mark he may come at the meaning of 'Langsam.' But a little farther on he encounters 'Leidenschaftlich bewegt,' which is harder upon him; and, a little farther still, 'Sehr frisch,' which is really too hard. This example has lately found imitators among the Scandinavians, who express their musical intention in words which a German of philological tastes and pursuits could doubtless make out, but which to the average German must be as unintelligible as to the average Englishman. Strange to say, the French, who take it for granted that everybody understands their language, or ought to, have not sinned in this way so much as the Germans. It is true that the scores of their operas are

covered with phrases like 'avec chaleur,' 'très simplement,' 'à demi-voix,' 'avec ironie'; but these may be regarded as 'stage directions,' addressed to, and inevitably intelligible to, those who are to play the parts as well as to sing the music to which they refer. Otherwise French composers limit themselves in their scores to a few native words—such as 'detachés,' 'doucement,' and the like. As for ourselves, our modern musical publications would indicate, what certainly is the reverse of true, that we are the greatest linguists on earth. It is needless to present examples of what everybody is familiar with; we have all seen, and see daily, title-pages, for instance, in which two, three, and even four languages are employed. (2.) Irrespective of its actual inconvenience, which I do not wish to overrate, this practice takes from music its noblest characteristic—its catholicity. We musicians are able to discourse in a language touching to the hearts, if not clear to the intelligence, of every people on the face of the globe; and we are furnished with an alphabet in which to write this language, which is not the invention of a single mind, but of a thousand minds; a thing which has marched on to its present perfection *pari passu* beside music itself; an alphabet so clear—to him who knows how to read it—that a musical composition, no matter of what intricacy, composed, let us say, at Moscow can, without any serious violations of the intentions of its author, and without his personal assistance, be performed within a few days, weeks, or months, in London, Paris, New York, or Melbourne, wherever there are artists to interpret it. Let us cherish this precious possession, and do what we can to prevent its acquiring a sectarian, provincial, or even national character, through the introduction of any peculiarities whatever.

The directions of which I have spoken were, up to a comparatively recent time, made all the world over in one language—Italian. And even to this hour the most Teutonic of musical composers are still obliged to resort to that language. In the score of which I have just spoken, Schumann's 'Genoveva,' there are as many Italian words or abbreviations of Italian words as there are measures—very often more. The words 'dolce,' 'sempre,' 'bassa,' 'soli,' 'divisi,' and the like are of frequent occurrence; and as for the contractions of 'piano,' 'forte,' 'crescendo,' 'diminuendo,' 'sforzato,' and the like, they may be counted by hundreds. Granted that Italy has not been observant of Andrew Marvel's caution—

'The same arts that did attain
A power must it maintain'—

granted that she has not held her own against such competitors as Germany during the last hundred years has brought into the field—are we to lose all veneration for the people whom the slightest acquaintance with musical history will show to have been once the musical teachers of all the world? Are we to kick down the ladder by which we have risen to our present superiority,

to turn a cold shoulder on an old friend, because we have become better off, and, it may be, wiser than he? Not, however, to throw more sentiment round this matter than it will bear, it does seem unwise to subject ourselves to the inconveniences of which I have spoken, when they can be avoided, by the simple process of using only one vocabulary, and that not a new or unaccustomed one, but one with which every musical people is at least partially familiar.

DISCUSSION.

The CHAIRMAN said he was sure the meeting would join him in returning a vote of thanks to Mr. Hullah for his valuable paper.

Mr. BANISTER expressed his entire concurrence in the remarks that Mr. Hullah had made. He himself had enunciated the same views to his pupils for now nearly a quarter of a century, and, indeed, embodied them in a book. He referred more especially to the nomenclature of the interval so commonly called the *augmented* or *superfluous* fourth, and its inversion, the (so-called) *diminished* fifth. He had said over and over again to his pupils, that the fourth in question was not an augmentation, nor the fifth a diminution—being, as Mr. Hullah has said, an integral constituent part of the diatonic scale. He had always taken the same view of the chromatic scale, and had therefore said that the altered minor scale, with the raised seventh and the unraised sixth, was no longer purely diatonic, and had made that a reason for maintaining the use, in conjunction with that chromatic form, of the form with the altered sixth and seventh in ascending. He had also always taken pains to impress upon his pupils what seemed to him the true theory—that all chromatic intervals are to be taken as augmentations or diminutions of the larger and smaller diatonic intervals respectively, and had therefore contended that the terms *augmented* and *diminished* should, in the nature of things, be reserved for such intervals.

Sir JOHN GOSS confessed to being one 'of the sinners' in this matter, because, in a little book which he had published a great many years ago, he had contented himself with following his predecessors, instead of amending their nomenclature. He had met Mr. Hullah on Saturday, and talked over some of these matters. He concurred in a great deal of what he had been prepared to hear that afternoon, and believed there was very little to be said against it. But in former days, when he first became a teacher at the Royal Academy of Music, Dr. Crotch, who was then the Principal and Professor of Harmony, in reference to the augmented or diminished intervals, used very often the terms '*extreme sharp*' and '*extreme flat*.' His old master, a very well-known musician of his day, Thomas Attwood, formerly organist of St. Paul's, called what we call the 'major third' a

'*sharp* third,' even if it were composed of two flats, such as G♭ and B♭. He would call a minor third a '*flat* third,' although it were composed of F♯ and A, or of G♮ and B♭. He had several manuscripts in the handwriting of Mozart, who wrote out the intervals for Attwood. In this list he speaks of the *superfluous* second, meaning what we now generally call the *augmented* second.

Mr Hullah asked in what language these lists of intervals were written by Mozart?

Sir John Goss replied they were in Italian. '*Superfluous*' and '*diminished*' were the terms Mozart used. These terms had been altering continuously. For instance, in the first edition of his book on 'Harmony,' where Dr. Crotch had called an interval *extreme* flat or sharp, he had called it *extreme* and *diminished*. In fact, he was afraid to go far away from the technicalities then in use at the Academy.

Dr. Stainer said it seemed to him that, on the question of the nomenclature of intervals, the real difficulty was whether we wished to name them as a part of a particular scale or in the abstract. If we spoke of F B natural in the key of C, that was one thing, but (as had been clearly pointed out) in the key of F it is quite another thing. He thought we ought to settle first the question whether we wished to have the power of naming an interval simply as it stands, or whether we may first ask the question what scale is spoken of. If simplicity were wanted, nothing came up to the German system of calculating all intervals from the scale of the lowest note, and in that state calling D to E a major second, D to F♯ a major third, and so on; and if the intervals were made less, calling them all minor, as D to E♭ minor second, D to F♮ minor third, and so on. But if you made the intervals larger they would all be called *augmented*; that is, you were allowed to speak without reference to the key. Dr Stainer quite saw the importance of the connection between intervals and keys, but thought it should be borne in mind by people who proposed a system for calculating intervals, that there was a distinction in relation to intervals in a given key and intervals in the abstract, and unless that was felt we should be liable still to meet with difficulties

Mr Stephens felt sure that they ought all to be very much indebted to Mr. Hullah for calling attention to the 'confusion of languages' which was now gaining ground, especially in Germany, in published music A strong feeling of nationality might make an Englishman, a Frenchman, or a German anxious to import his own language into his compositions, but he did this to his own wrong, because he rendered it unintelligible to other nations We now constantly met with compositions in which were found *Langsam* and the other words which have been adverted to—and not only these, but longer directions. In the early editions of some of Beethoven's Sonatas, the lengthened directions are given in the Italian language. For instance, in the Moonlight

Sonata, it says at the commencement, 'Si deve suonare tutto questo pezzo delicatissimamente e senza sordini.'

It was originally published in that shape, but subsequent editions very properly put it in a shorter form, so that those who were not familiar with the Italian language might be able to understand it. He thought the use of one language for musical purposes—for those few words which are really required in music—very desirable indeed. Of all objectionable things, however, the most objectionable was the mixture of languages, not only on title-pages, but even on the music itself. The other day he happened to take up a piece in which he found '*duro first note*,' meaning that the first note in the bar was to be played loudly. Surely the letters *sf* would have sufficed! A little further on there was 'p the bass,' meaning the bass to be played soft, and all the rest to be played loud. If you had put this into the hands of a German, he would have been unable to understand it. The inevitable result of a composer preserving his nationality, not only in the style of his composition, but in the language he uses, is to make himself unintelligible. With regard to the question of the naming of intervals, he did not think it desirable that we should go back to the very old practice of talking of the *greater* third and *lesser* third, and that for the largest intervals of a kind some epithet might be devised better than *superfluous*, which appears to him to be a very bad one. Sir John Goss had said that in the early edition of his work he used the epithet '*extreme*' occasionally for long intervals, but in later editions he found '*augmented*' substituted for it. He thought this scarcely worth much discussion, because he despaired of finding a term which would not be open to some slight objection in some direction or other.

Mr. Ellis, B.A., F.R.S., desired to say a word or two with regard to the difficulties that had occurred to him in the translation of Helmholtz. He had to deal with rather more numerous intervals than those which occur in the only style of music to which Mr. Hullah referred—tempered music, and especially equally-tempered music. It was necessary, for the purpose of Helmholtz, to deal with intervals which arose in what General Perronet Thompson had called, and in which he followed him, 'just intonation'—the natural scale of Mr. Hullah. It was necessary, for example, to distinguish the *major tone* and the *minor tone*. That was all very well, but it was necessary to distinguish two kinds of fifths, besides the just fifth. From D to A in the natural scale was no more a fifth, really, than from B to F, and when played upon an instrument tuned in that way, D to A was a frightful interval. The first instrument which he possessed, as he had mentioned at the last meeting, was a symphonium. As it was first tuned, it was tuned according to that system, and the D to A used to puzzle him, because it was such a horrible tone. Now those intervals which are less than another interval by a comma, he had generally distinguished by the word '*low*,' and those which were greater by the prefix '*high*,' because he had used '*high*'

and '*low*' generally for '*augmentation*' and '*diminution*' by a comma. He had spoken of *high* A (which is a perfect fifth above D) and of A simply (which is the major third above the F), and he had had to talk of *low* A, which occurs not so readily with this scale; but *low* D he had frequently to refer to, because it occurred in the subdominant key of C, and did not occur in C itself, and, in fact, led to an immense number of difficulties in playing anything in just intonation. With regard to the use of '*augmented*' and '*diminished*,' and so forth, he did not feel himself at liberty to go beyond common custom, and he had sometimes used the word '*superfluous*,' sometimes '*augmented*,' sometimes '*extreme*,' and so on, without any particular attempt at systematisation. He was not writing a book on the subject, and had only to introduce so much difference as the nature of his subject compelled him to do. He wished to say that this little innovation he had mentioned ('*high*' and '*low*') was merely for the purpose of enabling him to express himself, which he could not have done otherwise. With regard to another word which Mr. Hullah mentioned, the word '*tone*,' he was of course very much puzzled, as of course all persons who translate German books are. He recollected, in one translation made for Novello, of Marx's Introduction, tone when it signified one thing was always in italics, and when it signified another was always in common letters. He found that *tone* was not only an ambiguous word—that is to say, it was not only a word which sometimes signified an interval, and sometimes did not—but the words *second*, *third*, *fifth*, and so forth, were ordinal numbers; and he found it to be of importance to distinguish these, when they signified intervals, from the same numbers when they did not. He had, therefore, throughout the translation, used the arrangement of representing all intervals as beginning with capital letters. *Tone*, when it signified an interval, was written with a capital letter, and *Second* when it signified an interval had a capital letter. That is only a kind of *pis aller*, but he did not feel himself at all justified in using the word *sound* for tone. Tone is used in Helmholtz as a musical tone, and a musical tone is a peculiar kind of sound.

The CHAIRMAN asked if the original word was not 'klang'?

Mr. ELLIS replied that that was another matter. Helmholtz used the word *tone* for what he calls '*pendular vibration*,' but *klang* he used for what might be called a *compound tone*, and so he had translated it. He had found it impossible—as Mr. Duncan, in his book upon Acoustics, had found it impossible—to use the word *klang* for a compound tone, because it means in English something of a disagreeable tone, and Mr. Duncan in his Acoustics had brought forward that objection, which of course had occurred to him. He was very sorry to see that Professor Tyndall used the words *klang* and *klang-tone*—words which, like *overtone*, he thought, if he had used, he might as well have left the book in German; he had therefore not used them. He did not use the word *overtone* at all, but other words, of which *over-*

tone is a bad English alteration of a German abbreviation. The German word is *Oberton*, which is abbreviated from *Obertheilton*, which is the full word, and is sometimes used, and then of course it marks the distinction between *Theilton* and *Obertheilton*—*partial* tone and *upper partial* tone. Those are the strictly English words which he had used throughout the book. The word *tone* was used even in the old Greek for interval, and we had *diatone*, which is their name for our *major third*, which consisted strictly of two of their tones, the interval between the eighth and ninth, which was therefore different to any major third we can endure; for although our equally-tempered major third approaches it, it is flatter by a $\frac{1}{2}$ of a comma. There was, therefore, rather an objection to the word *tritone* in modern use (although he had used the word), because the three tones of which it consists are not of the same size. There are two *major* and one *minor* tones, and that has to be considered. Those are the difficulties which occur when one comes to theoretical expressions of music. Mr. Hullah is engaged, of course, entirely with the practical use of it, and he quite agreed with many points he had brought forward. For example, it would be a great advantage if we had a word for tone when it signified a musical *sound*, and another when it signified an *interval* between two musical sounds; but that word *interval* itself is a word which is not at all well understood by persons who hear it. They do not know what you mean by *interval* generally. They are not aware that they are dealing really with logarithms according to a very curious base—namely, that in which the logarithm of 2 is equal to 12.

The CHAIRMAN, referring to Mr. Hullah's objection to the word *tone poet*—which of course was merely a translation of *Ton dichter*—asked what was the origin of the word *tone*?

Mr. ELLIS replied that the word 'tone' was Greek. Its original use in Greek was for an interval; the word *tonos* is the Greek for interval. As to the use of the Italian language for music, of course he should quite agree, for he was one of those persons who think that everybody ought to be able to talk Italian, and therefore to make Italian the universal language of the world, simply because it is the easiest to pronounce, and the easiest to make one's self intelligible in. Perhaps it was most elaborated for music, the arts generally, for poetry, and for mercantile business; for all our bookkeeping was on the Italian system, and based upon Italian words, and, therefore, he should like to see it employed in music too. Still it was very difficult, when a person wants to express himself rather at length, to put it in the Italian language if he does not know it. For instance, the Italian directions referred to by Mr. Stephens in Beethoven's Sonata might as well have been Greek to a great number of persons, and therefore a shorter phrase in Italian, which would have been understood, would have been better. Hence it became difficult, especially in pieces written for beginners, to know how

much Italian you should impute to them, or whether you were to make them learn the Italian language at the same time that they learned music. I think they ought, but that is another matter, because some of the best songs which they have to sing are in Italian, and it is quite absurd for persons merely to learn how to pronounce Italian without knowing the meaning of it. Of course they ought to learn German also, because there are three languages without which you cannot get on—English, French, and German. But he was rather wandering from the subject. The great difficulty with regard to any of these alterations that are proposed is to get them adopted; each person has generally his own views on the subject. Those who are learners were ready to take up anything, but it was the teachers who were always very bad learners, whether in music or anything else; because when a person had become a teacher he had already made up his mind, and did not like to unmake it.

Mr. Hullah said it would take a great deal more time than was before the meeting to deal with all that had been said; but one of the last remarks made by his friend Mr. Ellis he would reply to first. He had spoken of 'all these alterations.' Now he appealed to the meeting whether he had proposed one alteration. He had proposed the adoption of one epithet, which he had used for the last 25 years, the epithet '*pluperfect*,' as applied to the exceptional fourth; but there was not another which he had mentioned which was not in occasional use. Perhaps, after all, he should be expressing Mr. Ellis's meaning more definitely if he were to say '*selection*' instead of '*adoption*,' as applied to the words he had proposed, and he really believed such selection to be perfectly feasible. He was afraid he did not see the force of Dr. Stainer's objection with regard to the necessity of looking upon intervals in two different lights. Why an interval which was a fact (just as a note is a fact) was not to be spoken of in a certain way he did not see. The note G was a fact, as we all know: it is the fifth of C, and the first of G, and the major third of E♭, and the seventh of A♭, and a number of other things, and must be so, and he did not see why of necessity we should have two different ways of naming the intervals. Neither did he quite understand how B♭ could be in the key of C or in the scale of C. Perhaps he had not quite been able to follow Dr. Stainer's meaning.

Dr. Stainer would be glad to be allowed to explain what he meant to have said. Mr. Hullah's observation had suggested to him that he had objected to the same expression; because he had said F to B is in the key of C, therefore so-and-so and so-and-so. He only wanted to point out that the whole question seemed to turn upon the fact, whether we are to look upon every interval, when mentioned, as being an ingredient of a key or an abstract musical relation. He had said, if we are to look upon F to B♮ as being in the key of C, we shall have to call it one thing, but if it be asked what F to B♮ is in the key of F, according to Mr.

Hullah's own showing, it ought to have another name, because it is of a different nature.

Mr. HULLAH said his answer to that would be very simple. The *tritone* was, so to speak, the seat of modern tonality, and no perfect form could be enlarged and no *tritone* lessened without modulation. If instead of C F you had C F sharp, you were no longer in the key of C, but in the key of G. If in the key of D you made the G *sharp*, you were no longer in the key of D, but in A, either major or minor. The singular characteristic of the *perfect* intervals was that they could not be altered without causing modulation; and thence, he thought, very properly, a distinction between those and the *imperfect* intervals was generally made in calling them *perfect* and otherwise. That was a point upon which he believed most authorities were agreed. In the case of the *imperfect* intervals, they could be changed with only a change of *mode*. From C to E was in the key of C—so was from C to E flat, only in the minor instead of the major mode. Every imperfect interval in the scale almost would bear that sort of alteration, but you could not alter a perfect interval without modulation. There was only one pluperfect fourth (as he should call it) in every scale, and the presence of that pluperfect fourth showed at once what scale we were in. What key is G C in? Nobody can say. What key is GC♯ in? In D. What key is G♭C in? In D♭. The introduction of the tritone, of its inversion into a scale, was, *ipso facto*, modulation, though it might be for a moment only. That was his view of the matter, and if it were a just one, the distinction between *major* and *minor*, and between *perfect* and something—call it what you like—was absolutely necessary. With regard to the names to which Mr. Ellis had alluded, they had reference to a science—the science of acoustics, of which he feared it must be said (though he really did not want to say anything offensive) that it had no practical bearing on musical art. The laws of acoustics might have done something for the structure and tuning of musical instruments, but, as far as the science of harmony was concerned, we should, perhaps, get on better without than with its assistance. The theory of harmony, as has been said before to-day, had been drawn from the practice of great musicians. Why were consecutive fifths forbidden? Because to a cultivated ear their effect was abominable. As to these major and minor *tones*, he did not for a moment question their existence, but he questioned their bearing on practical music. He did not believe that Mozart, or Beethoven, or even Mendelssohn, with all his great accomplishments, would even have known which by nature were major tones and which were minor. To the musical composer they are practically nonexistent—he has to do with equal temperament. Mr. Hullah confessed to being one of those persons who, it might be from deficiency of ear, was able to put up with a pianoforte from a first-rate maker, turned out from the hands of a first-rate tuner. And he found that with such a pianoforte, Joachim,

for instance (who is said to play in perfect tune) was able to take part in one of Beethoven's Sonatas. He wanted to know, if Joachim played in perfect tune, and, if the pianoforte with which he played was altogether out of tune, how it was that the two went together so delightfully. He thought, therefore, that with any set of names for major and minor tones and the like, they as practical musicians, and even as theoretical musicians, had nothing to do They had to deal with the facts before them, and those facts are the intervals found in a tempered scale. With regard to the further consideration of the matter he had the honour of introducing, it appeared to him that the Musical Association might settle everything among themselves, and make known their conclusions, which would have great weight. The question was how such settlement was to be arrived at. It could not be arrived at through discussions carried on as their usual discussions of necessity were But he thought that if a sub-committee were to be formed by the Association, for the consideration of the matter before them, it might come to some conclusion, and even submit a report of them to their whole body, probably before the end of the season So far as he was concerned, he would give up every name he had been in the habit of using for the whole of his professional life, were a body such as this to agree on an entirely different set for general use.

April 5, 1875.

ALEXANDER JOHN ELLIS, Esq., F.R.S., F.S.A.,

in the Chair.

ON THE PRINCIPLES OF MUSICAL NOTATION.

By John Stainer, Esq., Mus. Doc. Oxon., M.A.

Some apology seems necessary for reading a Paper on such a well-worn subject as Notation, especially before those who are not only familiar with it themselves, but in many cases occupied daily in teaching or explaining its principles to others. But Music has now become so universally a part of education, that it is of the utmost importance that we should have the best possible system of notation; and I take it, that the remarkable extent to which thoughtful musicians have lately turned their attention to this subject, and the many alterations which have from time to time been suggested by them, prove that some dissatisfaction is felt with existing systems. That there should be some opposition between rival methods is natural enough, but I think much of this opposition would disappear, could we be brought to consider calmly not so much the merits as the demerits of that particular system in which we live and move. For, having mastered its intricacies, we cease to believe in their existence, and having by long usage condoned its faults, we become loth to admit them to be faults at all. Those among you who happen to be special advocates of, and whose names are by common consent associated with, rival systems, will, I hope, understand that none of my remarks are intended to be personal, and that my only desire to-day is to ask you to consider calmly with me what are the true principles of Musical Notation, and how far those systems now in common use are built upon these principles.

The problem, how to write down graduated musical sounds, is not half so difficult as that of writing down spoken language. The latter has a much closer connection with the former than you might at first suppose. Many of you, no doubt, have been interested in tracing how successive generations have from time to time varied the spelling of their words, sometimes on phonetic

principles, sometimes on principles of etymology; frequently spelling is changed because pronunciation is constantly undergoing changes, owing to the fact that we have a physical tendency to use, in common conversation, that pronunciation which requires the smallest amount of exertion. The establishment of an unreasonable or cumbersome system of spelling has generally been followed by a reactionary wave of thought, striving at first too far in an opposite direction, though eventually content with a happy medium. Similar waves of thought have at different times upset and destroyed absurdly-complicated systems of musical notation.

In writing down words, we have to deal primarily with their articulation; in writing musical sounds, with their pitch. I say primarily, because musical notation has much to do besides describing pitch, and the spelling of words has much to do besides describing their articulation. In fact, the intonation of the speaking voice, or its elevation and depression in pitch, is one of the most subtle characteristics of different languages. Attempts were made by some ancient nations, the results of which remain in certain European languages to this day, to describe by signs their intonation of speaking, and thus secure to future ages the sweet keyless music of their poesy. There can be little doubt that the Hebrew accents were of this character—signs for securing good reading, but the interesting part of their history is that they afterwards grew into a most elaborate system of musical notation, the interpretation of which will be a valuable study for any of you who feel inclined to throw yourselves into a hotly-contested battlefield, or are anxious to discover a subject on which you may form any new theory you like, and then challenge the world to disprove it. We are all familiar with the force of the accents, added late in its history, to the Greek language: how the voice should rise with the acute, fall with the grave, and move up and down again with the circumflex. But they have never been endowed, like their Hebrew prototypes, with a musical value. Perhaps no language is capable of such varied intonation as English. If you give the subject consideration—and it is a subject worthy the study of musicians—you will find that not only are words altered as to their meaning and force by the relative pitch of their component syllables, but the whole gist of sentences often depends upon it. Yet we have no signs of intonation in our language.

I said, musical notation has primarily to deal with pitch, because this is by far its most important duty. But the extent of pitch in music so far exceeds the intonation of words, that we put words to sounds and carry them up and down for several octaves. An *artificial* force can thus be given to the *natural* intonation of words, with the marvellous emotional effects of which we are all familiar. I wish song-writers would expend a little more thought on this marriage of words and music.

The notation of pitch, as far as I can determine, has never

been of more than three kinds—alphabetical,* imitative, and by the ladder. This is not a strictly logical division, but for my purpose to-day I know not how I can better express myself. By alphabetical, I mean all those systems in which *letters of the alphabet*, in their common or in a slightly modified form, have been used as signs of musical sounds of various degrees of pitch. By imitative, I mean the drawing of short lines to describe, by their direction, the direction of sound up or down. By *the ladder*, I mean such systems as that we have now in common use, in which horizontal lines are drawn and notes placed upon them, standing in a graduated relation of pitch to each other. The alphabetical system reached its highest cultivation among the Greeks, who, as you know, apportioned every arrangement of sounds to a mode, a letter or distorted letter describing the pitch of each sound. It is probably of Asiatic origin.

The imitative system has had its best exponent in the method of the early Greek-Christian Church. In this, what was originally the motion of the director's finger or hand, used for describing the rising or depression of sounds, was afterwards drawn pictorially, and the signs so drawn, when placed on paper, could be interpreted in the absence of the director of the music. My belief is, as I have before said, that the Hebrew accents, or certain musical signs which appear over or under words in some of the more ancient books of the Holy Scriptures, to which I have just alluded, belong to this class. In both these cases, however, the original signification, and perhaps even the origin of the terms themselves, was in time forgotten, and they became merely conventional forms interpreted in various ways, as national character or international intercourse from time to time suggested. I think most persons are agreed that the mediæval system of *neumes* was originally imitative, and, as in other similar cases, afterwards conventional.

Of these three systems the imitative is decidedly the weakest. Singers and players were constantly liable to render its signs in diverse ways, and inasmuch as two priests could hardly be trusted to sing plain song together from this notation, part-music, except from memory, must have been an impossibility. In fact, the shortcomings of this system directed men's thoughts to the necessity of finding something better, and the 'ladder' system was the result. We will say no more, therefore, about the imitative system, and our consideration will be devoted to *letter* and *ladder* systems.

If a representation of pitch were the only function of notation, there could be little doubt as to the superiority of the ladder system, inasmuch as a high sound stands high on the ladder, and

* To these the *numerical* system should have been added. The use of the numbers 1, 2, 3, 4, 5, 6, 7, instead of the letters A, B, C, &c., or of the words *do re mi* is common in France, but it does not differ in principle from an alphabetical system.

a low sound is low down. But the art of music, especially in its modern development, is largely, perhaps chiefly, concerned with the relation of sounds to one another. This arises from the recognition of the true force and meaning of the Octave system. When once it was acknowledged that sounds repeated themselves octave by octave, it became evident that any definite series of sounds lying between but not exceeding the bounds of an octave, could be repeated to either limit of practicable sounds. But the most important discovery which should have followed from the natural recognition of the octave, seems only quite lately to have dawned upon us; it is this: if your scale-sounds lie within an octave, the signs which represent them in one octave will also represent them in another, if only some special sign of octave pitch be given. The Staff notation profits by this fact, and uses a clef as an octave-pitch sign. The Tonic Sol-faists profit by it, for they use only seven signs, and make them do duty in all conceivable pitches.

It seems strange that this important truth should have been so tardily established. In the system of tetrachords, the second of any two successive tetrachords necessarily presented to the ear some sounds not included in the first. The Greeks did their best, however, to remedy this fault by an ingenious system of disjunct and overlapping tetrachords. Mr. Chappell, in his learned work just published, has cleverly argued the claims of the Greeks to the octave system. But he will not, I think, blame me for saying that it was a development of their system, not a part of its essence.

The inconveniences indissoluble from the use of tetrachords reappeared in the mediæval system of hexachords. Thus, on a harpsichord, the Ds which we should call throughout a pianoforte as simple D, or at most as 'double,' 'single,' 'little,' 'one-stroked' D, and so on, were called 'Double D Sol Re,' 'D solre,' 'D lasolre,' 'D lasol'; those names being required to show in which hexachord, or collection of six notes, each particular D occurred. In short, the complications of both tetrachordal and hexachordal systems arose from an unacknowledged attempt to adapt them to the more useful and more natural system of octaves.

The Octave system is now fortunately supreme; and in consequence, any new system of notation invented, or old one improved, must be founded on, or linked to this. Only two systems of notation are now in use—the ordinary or Staff notation, and the Tonic Sol-fa notation. I take it for granted you all are well up in the common or Staff notation, but as you may not all know the Tonic Sol-fa system, in which letters are used as signs of sounds, as I proceed I will briefly explain it. But as Tonic Sol-fa is a most unmeaning term, I shall hereafter call it the *Letter notation*, and our common set of five lines, the *Staff notation*.

With your permission, I will now compare carefully, and I hope with impartiality, the merits and claims of these rivals. But first let us ask, what is the actual function of notation? It

is, to represent to the eye the pitch, duration, and key-relationship of sounds. You will observe that I do not place Quality (*timbre*) or Quantity (intensity) of sound amongst the requirements of musical notation, because plain directions in language can be given for both these, by naming the character of instrument or voice which is to be used, and by using such words as *loud*, *soft*, *sweet*, or their conventional equivalents.

Pitch in music comes before us in two aspects. There is that definite position of a sound in the long range which is appreciable to the human ear (say seven to ten octaves), which we call *absolute* pitch, and there is that scale-relation of one sound to another which we call *relative* pitch.

First, then, as to *absolute* pitch. In the Staff notation, as you all know, it is represented by a clef. We have, speaking roughly, the treble and bass clefs, between which lies the important central sound known as middle C. These clefs, with their ten lines and intermediate spaces, eked out by leger lines temporarily added, suffice for the representation of nearly all the sounds required in music. We may say therefore that, subject to certain modifications,* the clef is to us the sign of absolute pitch. It is quite unnecessary to enter here into the question of these modifications, because they do not affect the *principle* of clef-signs. Nor does the unfortunate disagreement between French, medium, and concert pitch affect the *principle* of fixed sounds, because a compromise may at any time reconcile them, and if it should not, we are all of us able to give the pitch of middle C, within a semitone.

How does the Letter system describe absolute pitch? I think not very clearly, or at least not in a very philosophical manner. At the commencement of each piece and at each change of key it is said Key A, Key B, and so on. But the voices of women and boys have to interpret this as pointing out the pitch of the Doh lying in the most important octave of their voices, and men-singers must interpret it as pointing out the sound an octave below that of the treble parts. Upon comparing the method of describing absolute pitch in the two systems of notation, I think it impossible to avoid coming to the conclusion that the Staff system is the best. I ventured to suggest, during a discussion at one of our meetings here, that Tonic Sol-faists would be wise to take a standard pitch, and instead of saying at the commencement of a piece Key A, B, &c., to say *Doh equal to* so many *vibrations*. I still think this suggestion worthy of their consideration.

Next as to notation of *relative* pitch. At first sight, the common Staff notation seems to be delightfully simple: a high

* The modern use of the G clef, both for the treble and tenor parts does to a certain extent deprive clefs of their claim to be signs of absolute pitch. The late Mr Oliphant suggested and used a sort of duplicate sign to distinguish the tenor part from the treble. Some difference of shape seems desirable.

note stands high, on or between the lines, and a low note stands low; notes on consecutive lines and spaces form a properly graduated series. But I fear this supposed simplicity gradually disappears when we put it to a practical test. For this reason, the graduated series of notes represents only the key of C unless certain signs are placed to show the sharpening or flattening of those notes required to form a new scale. Thus, if I write down the following, either with a Treble or Bass clef,

I have merely written a series of notes proceeding upwards, but the actual size of the steps may be altered and varied in at least fourteen ways. The player or singer, therefore, who looks at a piece of Staff notation receives nothing more than a general intimation when to go up and when down; he is in utter ignorance of the actual intervals to be played or sung, until he can discover and carry in his mind the key-signature. To have to carry this in the mind is a real tax on the performer, and it ought, surely, to be made as unnecessary as a constant remembrance of time signature.

Now in the Letter system, seven letters represent at once the seven words of the sol-feggio and the seven notes of the scale, thus: **D R M F S L T**, all sounds an octave above those are represented by a stroke above the letter, thus, D¹ R¹ M¹ F¹ S¹ L¹ T¹; all sounds in the octave below are represented by a stroke below the letters, thus, D_1 R_1 M_1 F_1 S_1 L_1 T_1. Now the relation between these letters is always that of the notes of the diatonic scale to each other; thus, D to R will always be the interval between the key-note and the second of the scale; D to M, that between the key-note and its third, and so on. When, therefore, a performer is looking at a piece of this Letter notation, he has the disadvantage of not being able to obtain at a glance that general intimation of movement up or down which the staff gives; but, on the other hand, he has the inestimable advantage of knowing exactly the interval between them, for it cannot vary, whatever be the key. Thus, D to M is *always* a major third to the Tonic Sol-faist, whereas *do* to *mi* may mean half-a-dozen different intervals on the staff.

In comparing the method of describing relative pitch in the two systems, we must admit that both have their peculiar merits: the Staff in its little picture of comparative height and depth, the Letter notation in its representation to the mind of an exact and known interval when the pitch of *any* note is given, whereas the *pitch* of one of two notes is not the least assistance to the reader of Staff notation in finding out the exact interval to the other.

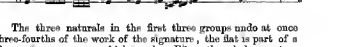
As to duration of sounds. As you all know, in the Staff

notation, the shape of notes describes their proportion to whatever unit is selected, thus 𝅝, 𝅗𝅥, 𝅘𝅥, &c Nothing could be simpler. But in the Letter system there is no possibility of showing the relative length of sounds, unless a whole or part of a bar be taken, and then divided into subordinate parts by commas and semicolons. Of course, it would be quite easy for the shape of the letters to be made to describe their proportionate duration; thus, a large D might describe a semibreve, a smaller D a minim, and an italic *d* a crotchet For ordinary hymn-tunes this would answer all purposes, but I believe it has been found impracticable in a higher class of music In common notation there are eight different kinds of notes (from the breve to the half demi-semiquaver inclusive); to match this, therefore, the Tonic Sol-faists would have to find D's, R's, M's, F's, L's and T's of eight different shapes,—an impossibility, unless the Greek or perhaps even the Hebrew alphabet were called into requisition. In deciding the merits of the two systems then, with reference to this point of proportionate duration of sound, our verdict must be strongly in favour of the Staff system Before leaving this part of the subject, I should like to point out what might have been called an oversight in our common system, had our notation been an invention and not a growth. The whole note is an open note 𝅝; the half-note open, but with a tail 𝅗𝅥; the quarter-note should therefore have been a black note *without a tail*, thus 𝅘, and the eighth note black with a tail, thus 𝅘𝅥. You will find crotchets quite as distinct *without* their tails as *with* them; and had this very evident arrangement been adopted centuries ago, tons of printer's-ink might have been saved which have been uselessly wasted on crotchet-tails; morover, our eighth note or quaver would have required no crook, the semiquaver only one, the demi-semiquaver only two; and, further, those ecstatic pianists who sometimes now delight to use notes with five tails would be able to make their rapid passages exactly *twice as impossible* as before, without multiplying tails

I have now reached the most important part of my subject, namely, the comparative merits of the two systems as showing key-relationship. In both, the performer at the commencement of a piece is informed what key it is in; in the Staff by the key-signature, in the Letter notation by a plain statement—*Key of* A, B, &c. Now we will first compare them under an hypothesis that there is no such thing as modulation or change of key in existence. Let us suppose then a movement with three sharps in the Staff, and the same movement in Letter notation in *Key of* A. In the former, as the eye leaves the left-hand corner of the line, the mind has to carry with it the fact that three, and only three sharps appeared in the signature; and, should this fact for one moment be forgotten, wrong intervals will inevitably be taken by the voice or finger. In the latter, nothing has to be carried in the mind of the performer as he proceeds, for every note bears

to the one which has preceded it, an invariable and constant relationship. I really think we must in this case give the preference to the Letter notation. We all know how sorely a child's memory and patience is taxed by having to look out for notes affected by the signature, in pianoforte-playing; but in vocal music this influence of the signature becomes even more troublesome, because, as I have before said, the whole of the intervals may be affected by it. But more on this by-and-by.

Now, as to a movement containing modulation. In the Staff notation, a change of key-signature will always show at a glance when there is a modulation. Similarly, in the Letter notation, a change of key can be at any time expressed by saying what the new key is, and what name the last note of the old scale will be called by in the new scale—or, as it is termed, *by a bridge*. But the fact is that modern music consists largely of a series of quite temporary changes of key, so temporary that it is not thought necessary, or even desirable, to introduce a new key-signature, accidentals (sharps, flats, and naturals) being sufficient to show the notes requiring alteration, until such time as the original key is restored. This appears to be delightfully simple, but practically it constitutes the chief difficulty in reading music, whether vocal or instrumental, especially vocal, and for this reason—an accidental influences all notes of the same degree until the end of the bar, unless counteracted by another accidental. We thus compel the performer to distinguish between a complication of orders and counter-orders. The key-signature says, peremptorily, 'Play in such a key', several accidentals appear and say, 'No! here are counter-orders that the key is displaced till the end of the bar;' but before the end of the bar is reached, some more accidentals (staff-officers) rush up and say, 'The counter-orders are countermanded, and the key is to be restored at once.' I append a very simple and commonplace passage when heard, which, however, involves quite a long explanation if looked carefully into.—

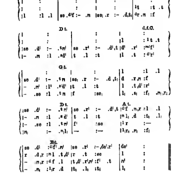


The three naturals in the first three groups undo at once three-fourths of the work of the signature, the flat is part of a chromatic progression which involves F♮, so the whole signature is now useless; the remaining sharps are required solely to restore the key, and the B♮ is required for the purpose of raising the B♭ which was chromatically altered eight notes before it. Such passages are of constant occurrence. From long observation, I have little doubt that modern music would be vastly simplified in appearance, and so made more easily readable, if the influence of accidentals had been always limited to the actual notes to which they are affixed. Surely, it would be more

easily intelligible to a child to say, your signature reigns supreme except when a countersign is *actually* affixed, than to say, bar after bar may be deranged and dissociated from the key-signature by the introduction of accidentals, and, if the use of the accidentals is not wanted throughout the bar, sharps and flats are fetched from the signature for the purpose of reasserting their authority If you take up a complicated piece of music—such, for instance, as Beethoven's Sonata for the Pianoforte, Opus 111, Bach's works generally, Spohr, Brahms, Wagner, &c—you will discover that the great quantity of troublesome accidentals sprinkled over the page is largely due to the constant repetition of signs which have already appeared in the signature. Enthusiasts say that our common notation is really remarkably easy, that its difficulties are merely fanciful, and that those who cannot master it are deficient in intellect. It is easy for those who, like most of us here present, have had the inestimable advantage of learning the Staff system in early years, to read it rapidly and with comparatively few mistakes; but it is difficult nevertheless, chiefly owing, as I believe, to this unnecessary ordering and counter-ordering of signature and accidentals. You all must be aware that some very distinguished singers and players have been and are but *poor readers* of music, and that, *as a rule*—there are many exceptions—the amateur is distinguishable from the professional by his inferior power of reading; and it must be borne in mind that this arises not so much from a mechanical or physical incapacity to play the notes written, but simply, because the amateur has, as a rule, less frequent practice in the rapid mental efforts which our Staff notation imposes.

It may, however, be some consolation to the advocates of the Staff notation to know, that in rapid changes of key, the Letter notation is as difficult and complicated, or indeed more difficult, than the Staff system. A clever and well-informed teacher of the Letter system, under whose tuition I placed myself some years ago, translated one of the Choruses from S. Matthew's Passion, 'Let Him be Crucified,' from the ordinary to the Letter notation at my request I append it, so that those who are interested may compare the two:—

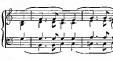
LET HIM BE CRUCIFIED.

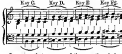
KEY D. Lah is D. (From BACH'S *Matthew Passion*.)

There is yet one other reason why the Staff notation becomes difficult during modulations; it is this—composers have apparently a great antipathy to frequent change of signatures. In sonata-form in the major key, when the second theme is, as commonly happens, given in the key of the dominant, it is not considered etiquette to change the key-signature; so, in pupils' first essay in this form, the master may safely look forward to a few

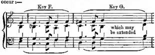
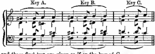
or many omissions of the accidentals required to form the new key. You will all endorse what I say, when I remind you what a frequent source of interruption the omission of such accidentals becomes at orchestral rehearsals. The fact is, the composer's *mind* goes completely into a new key, when the development of his Form demands a modulation; in adding accidentals, therefore, his fingers have to positively act against the dictates of his conscience.

It will be observed that in certain cases, namely, when a complete change of key has taken place, but where the author has not changed the key-signature of his Staff notation, the Letter system shows a decided superiority, for here the new key has been formally announced and accidentally altered sounds have been discarded altogether.

Composers, by being too chary of introducing new key-signatures in their staff, have unnecessarily multiplied the number of accidentals, which in some music seem to swarm like a plague of flies. But, on the other hand, in the Letter system the key, or pitch of Doh, is changed, not too seldom, but I think very much too often, though in one class of examples, from which I will by-and-by cite, not often enough.

Just now I spoke about the confusing effect of those accidentals which must necessarily be introduced in the Staff system upon a merely temporary modulation. In the Letter notation these temporary modulations—call them *transitions*, or whatever you like—are, I conceive, no less a source of difficulty. The Letter system professes to move its Doh, with every change of key; but if in a movement a sequence of short phrases occurs, which passes through a series of keys, the Tonic Sol-faists make great efforts not to change the Doh. Take, for example, the beautiful hymn-tune 'For those at Sea,' as given on page 84 of Mr. Curwen's Book on Harmony. The second line (of words) is rightly turned, in the Letter notation, into the key of G, but the third line runs thus:—

These two limbs of a beautiful sequence, which might be indefinitely prolonged, are actually given in the Letter notation of the key of G. Of course, the first is as palpably in the key of C as anything possibly can be, and the second is in the key of D; and there can be no

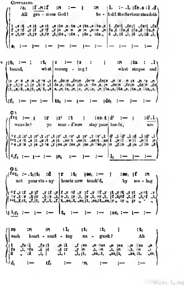
more reason for saying that these two are in the key of G than any other sections of the sequence, if it were prolonged thus —

and so on through G♯ (A♭), B♭, and home to C.

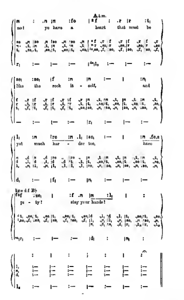
In saying that any one of these sections is in the *key of G*, the Tonic Sol-faists are not true to their own principles. In the same tune the two first sections of the following sequence occur :—

and these first two are given as if in the key of C.

In these treating sequences, or *sequential oscillations*, as the Tonic Sol-faists rather absurdly call them, I think they are wise, but they have ceased for the time to be Tonic Sol-faists at all. To say, as they do, that the ear does not go out of the first key in cases such as these, is, I am afraid, only an ambiguous form of acknowledgment that in the Letter system, rapid changes of key, if carried out conscientiously, would be complicated and cumbrous. One more example, and I will pass on. The recitative, 'All-gracious God,' No. 60 of Bach's 'St Matthew Passion,' has the key-signature of C, and consists only of twelve bars. In these twelve bars it passes, according to my humble power of analysis, through at least *nineteen keys*. Now, difficult as it appears in the Staff notation, I am quite convinced it would be far more difficult in Letter notation, with each remove of key strictly given. Here it is:—

ALL GRACIOUS GOD.

KEY F *Andante patetico.* (From BACH's *Matthew Passion*)




no! ye have a heart that must be
like the rock it - self, and
yet much har - der too, have
pi - ty! stay your hands!

I have already tried your patience much too long, but allow me to say a few more words by way of summing-up. In representing absolute pitch, Staff notation excels. Your key-note is one and, as long as you choose, immutable. In the Letter notation your key-note is—*anywhere.* In Staff notation, your treble-staff, and bass staff, with the intermediate central C, remain a fixed standard. In Letter notation your Doh may march up and down eleven semitones at any time and in any way.

Now, on behalf of Letter notation let me say, that in it the relations of the seven sounds of the scale are so plainly evident alike to eye and ear, even when chromatically altered, that the correct singing of intervals becomes a matter of comparative ease; whereas, in the Staff system, intervals become stumbling-blocks to singers because their exact size depends not only upon a vivid remembrance of the scale of the original key-signature, but upon the counter-orders issued by accidentals, which may at any moment themselves be countermanded by signs fetched from the signature for the purpose. In representing minor keys, both systems have grave faults. In expressing proportionate length of notes our Staff notation is admirable. The Letter system can never be universal until its time-notation is completely altered. The indistinctness of the time-notation will, I believe, be fatal also to an ingenious system just imported from the Continent which combines Letters and Staff.

But an important question here presents itself to us: Do we require one and the same system of notation for voices and instruments? I think not; for this reason: I believe that in ninety-nine cases out of every hundred, the first impulse of a singer is, when a vocal part is placed before him, to consider the *relations* of the sounds to the key-scale, and to each other. I am equally certain that an instrumentalist instinctively looks upon a note as representing a *locality*: if he is a pianist, it represents to him the position of a certain black or white key; if a violinist, the position his finger should take on a string. For example, suppose I write a piece in the key of C, but on trial, I think it not quite bright enough, and rewrite it in C♯. The singers have precisely the same parts to sing, they are only slightly altered in pitch—so slightly, that probably not one in a hundred observes it; yet, in the Staff notation, I have taken them from the simplest known key into one which has seven sharps in the signature, involving double-sharps and all kinds of abstruse signs in modulating. What have the poor singers done, that they should, because singing my work a mere trifle higher in pitch, be dragged from the pure sunlight of the key of C into the tangled mazes of seven-sharps-C and its related keys? The Tonic Sol-faist does not play singers such a mean trick as this: he merely puts his pen through the expression Key of C, and writes Key of C♯ in its place; all his Letter notation remains precisely what it was before. This is of course an extreme case, but stated thus broadly, it gives the Letter notation for *vocal* parts an advantage over the Staff which is immense.

But with instrumental music the case is far otherwise. Suppose, if you please, that my violin accompaniments to this hypothetical composition in the key of C were copied in Letter notation. I write as before, not Key of C, but, instead, Key of C♯; then, every single point on the strings becomes to the player moved,—his fingers cannot cross his strings at the same point as before; he has to think out as he plays, not only the relative pitch of the letters to each other, but a new problem—namely, whereabouts on the strings the altered pitch will take him. No wonder that a Tonic Sol-fa violinist should be dazed, seeing that he must contemplate his four strings as containing *an infinity of potential Dohs.* So too in the case of the pianoforte: a movement in the key of C written in Letter notation is totally changed for the performer, by saying Key of C♯, instead of Key of C—thumbs will not be able to go under fingers where they did before, nor will they be able to take the same position as before, in chords or arpeggios. This inaptitude of Letter notation for instrumental music must, I think, be conceded even by its warmest advocates. But, why not publish well-known oratorios, with voice-parts in Letter notation, and accompaniment in Staff notation?

To say that Letter notation is not apt for instrumental music is, it must be confessed, to say that it cannot be used for the higher walks of our art. I believe it cannot.

But, ought the Letter notation to be scouted and condemned *in toto* because its scope is somewhat limited? I think not. It has enormous advantages for simple vocal music, such as chants and hymns, as any of you can find out if you give it a trial. I assure you, if I were called upon to rear a church choir in an agricultural district, I should unhesitatingly begin at once by teaching the rustics Letter notation, as being the simplest and easiest method of attaining a simple and easy end.

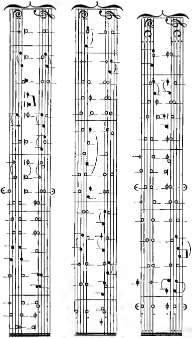
An objection will here be raised, to the effect, that it is undesirable to teach any person a system which he must throw aside on reaching, or aspiring to reach, the higher branches of art. It will be said, 'You might as well have two methods of writing language—one for common conversation, another for science.' There is some weight in this objection, but not so much as appears on the face of it. Let me remind you, that we do use two notations for properties and measurements. You teach a child arithmetic with its *numbers* and their invariable relation, but when he wishes to handle abstract quantities and variable relations, you teach him algebraical signs. The time bestowed on the study of arithmetic is not lost to the student of algebra, nor will the time given to Letter notation be thrown away if the Staff notation be afterwards mastered.

There is one class of persons to whom, I believe, the Letter system, with its constant relation of letter to letter, is more troublesome than the Staff notation, with all its faults: I mean, those who have an acute sense of absolute pitch. Such persons can sing any interval correctly without reference to the relation of the

notes which form it, because they know where each note separately *lives*, so to speak. I am sure there are many here who possess this gift, and I believe it to be more common than is generally supposed; but those who possess it are often unmerciful enemies of the Letter system, because it bothers instead of assisting them. In fact, when singing from it, they have to *transpose* all music not in the key of C. I hope my criticism of the Letter system will be considered the more impartial, when I say, that I have been from childhood gifted with a sense of absolute pitch, and that when singing to my Tonic Sol-fa tutor in Oxford, I was really going through a very troublesome course of Transposition. As the study of music becomes general, I believe the number of people born with a sense of absolute pitch will proportionately increase. If this sense ever should become universal, Letter notation will die a natural death. It is not my duty to refer here to the supposed superiority of the Letter notation, as causing singers to take natural instead of tempered intervals; but I should like to say, that a really educated singer or violinist is as certain not to sing or play out of tune except from physical causes, as if he had not only Letter notation before him, but a complete explanation of the derivation of every chord. In the higher spheres of great mechanical skill combined with refined sensitiveness, the mind becomes its own Intonator, and needs neither letters nor signs to show sound relation.

In conclusion, I should like to bring before you a system of notation for absolute pitch, which seems to me to have great merits.* I have said that one of the best features of our Staff notation is that the shape of its notes shows their duration. Now, as one of the chief difficulties in reading music arises from the influence of key-signature and accidentals, why should not the shape of a note show whether it be sharp, flat, or natural? This can be easily done by using *round* notes only for naturals or normal sounds, *diamond* notes for sharpened sounds, *square* notes for flattened sounds. No other alteration need be made in the present system—semibreves, minims, crotchets, &c., being used just as before, only in these modified forms. The adoption of the round, square, and diamond entirely supersedes key-signature: for in the key of G, the note F will be diamond; in the key of D, F and C will be diamonds; in the key of F, B will be square, and in the key of B♭, B♭ and E♭ will be square, and so on. But there is also the great advantage in this system of being able to dispense with *accidentals*, for when F♯ has to be made F♮ a round note is used instead of a diamond; and when B♭ has to be made B♮ a round note is, of course, used instead of the square. I have tried several difficult passages written out in this notation, and have been surprised at its

* Since writing the above I have found that the proposed system has been used, to a limited extent, both in England and America, and with marked success.



simplicity. The mind has nothing to carry on with it; every note tells its own tale both as to time and pitch. For the double-sharp I propose to put a sharp against a diamond; for a double-flat, a flat against a square. I append a chorale by Bach, noted for its chromatic harmony, as a proof of the simplicity gained by this notation. Its weak point is that it is very difficult to write in manuscript. But engravers could be easily taught to transfer music in the ordinary key-system into the new form. I have no wish to disturb the present form of writing music, but I must say that it would be a great gain to children and adult beginners if pianoforte, harmonium, and organ music were thus printed; for as soon as the white keys of the instrument were understood, no knowledge of key-signatures is needed, but any piece of music could be read without chance of error; the diamond note invariably representing the *next key* to the right of the white or normal note, the *square* note the *next key* to the left, and the *round* note the white key itself. After learning to read music thus, it would be most easy to say to the student, 'Sharps in the signature direct that all notes on those lines are to be played as diamonds; flats in the signature similarly show what notes are to be *square* throughout; naturals make notes equal to *round*.' I am not without hope that such an evident improvement in notation will have a fair trial. It is not, as far as I know, protected by any 'patent,' and I believe that an enterprising publisher, who would issue pianoforte tune-books and simple pieces for the harmonium in this notation, would meet with much encouragement.

DISCUSSION.

Dr. Stone said he differed from Dr Stainer as to the existence of any *absolute* pitch, and mainly on physiological grounds, although metaphysics underlay the question. He did not think that human beings had any innate ideas whatever, and certainly not any innate sensations, and he was inclined, with Locke, to look on a child's mind as a blank sheet of paper as to pitch of all sorts as well as all other subjects: he should also deny the presence of absolute pitch in the mind, because there was no such thing; and, as he understood, Dr. Stainer himself admitted this, because the pitch in Handel's day was not what it is now. He (Dr. Stainer) had spoken of three different pitches—the French, the medium, and the sharp pitch—whereas if there were any innate pitch it must always be the same. Dr. Stone did not know which of the three was to be considered as preceding the rest, if any of them were innate. There were also other arguments against this notion. All the senses seemed to be acquirements; and, at any rate, a musical ear could hardly be considered a sense at all, but was essentially an acquirement, for three parts of the world did not possess it, and if it were innate, the vast number of un-

musical people would be of defective sense, and must be ranked among idiots. He would not go further into the subject then, as he intended to refer to it on another occasion, when he could do so with more accuracy and detail.

Mr. BOSANQUET thought the existence of a sense of absolute pitch could hardly be questioned, merely because at different times there had been different absolute pitches attributed to the note C. What was implied by the expression was that a person had the power of remembering continuously the note sounded by a certain key on the instrument he commonly used, and this power was an undoubted fact. Sir Frederick Ouseley had told him that the very first time he heard a note of which he was told the name he was able to remember it, and had remembered it ever since, so that he had, to all intents and purposes, the sense of absolute pitch. There was a great deal to be said on the theory of notation in the stricter sense. One thing had rather astonished him—namely, that Dr. Stainer was so enthusiastic an advocate for equal temperament.

Dr. STAINER. Not so much so as I was.

Mr. BOSANQUET was of opinion that equal temperament was the basis, as many considered, for all calculations and arguments, and he was therefore rather surprised that nobody had attempted to devise a notation by which twelve notes of equal temperament could be taken as the basis to be indicated. He had himself devised a notation of this kind, the nature of which he would briefly indicate. Taking an ordinary staff of five lines with the middle C on the ledger line below, and reckoning each line or space as a semitone, you arrived at the octave on the first ledger line above, and therefore by using four staves, one above the other, there would be the means of representing four octaves, and the difference between the tones and semitones would be seen at a glance by the position of the notes on the staff.

Professor W. H. MONK said he would confine his remarks to two points alluded to in the paper. If, as Dr. Stainer said, the multiplicity of signs, such as sharps and flats, were a disadvantage, and if it were a disadvantage that sharps and flats in some cases only affected the notes in one bar, and in other cases all notes of the same name, there seemed to arise the question, whether or not our forefathers did a wise thing at all in adopting a system of scale-signature, and whether all scales ought not to be indicated now as they must have been originally, by the interposition of sharp or flat signs as often as those signs were necessary. One other point had always struck him with regard to the question of simplicity as between the established notation and what was called the Tonic Sol-fa notation—namely, that there was a mistake in saying that in the latter nothing had to be carried in the mind of the student; for it frequently happened that, as the voice part progressed, there were directions that the key should be A♭, B♭, C♭, or whatever it might be; and consequently the reader had to keep in mind, in the first instance, the signature, with the qualities

of the intervals as originally used for the natural scale, and then the variations which occurred from the change of pitch as you proceeded to modulate into different keys; so that he would not admit that there was that distinction which had been mentioned, that in the Staff notation certain things had to be remembered, and in the Tonic Sol-fa nothing at all.

Dr. Pole said that reference had been made by Dr. Stainer to one advantage of the ordinary notation—namely, the immense facility it gave of reading music without performance. Mr. Hullah, in some of his works, had referred to the great advantage possessed by those who could (as was the case with most educated musicians) form an idea of a piece of music, by perusal, without hearing it. Most people accustomed to music could form an idea of a psalm-tune, or a chant in four parts, by simple inspection, and those who were more highly trained in the art could form an idea even of an instrumental piece in score; but he (Dr. Pole) did not know whether that would be possible in the Tonic Sol-fa notation, even in the case of a psalm-tune. He certainly did not think it could be done with an instrumental score.

Mr. McNaught said all trained Tonic Sol-faists had a very clear idea in their minds of the sound of what they looked at in the Tonic Sol-fa notation—whether it were a four-part vocal piece, or even an orchestral score; in fact, it was the practice of some Tonic Sol-fa conductors to translate the score into the Tonic Sol-fa notation, in order to make it more easy to their eye. It would be admitted by all that even to an experienced conductor it was a matter of difficulty, in looking at a complicated orchestral score, to imagine the effect which would be produced, the parts for the different instruments being written in different clefs, and in different ways, in order to accommodate the various instruments. To a Tonic Sol-faist, however, it was as easy to read an orchestral score as a psalm-tune, because all the parts were written in the same key. In reply to what had been said by Dr. Monk, he would merely say that a Tonic Sol-faist had *not* to retain anything in his memory, except the one key; he learnt the seven tones of the scale by the mental effects, and not a number of intervals from one note to the other.

Professor Monk said his remark had reference to Dr. Stainer's observation, that in the Tonic Sol-fa system the performer had nothing to carry in his mind. He could not see how an intelligent musician could read music from any system at all, and yet have nothing to burthen his mind with; for reading seemed to him to be altogether a mental operation.

Mr. Hullah said he had no doubt Dr. Stainer was aware, although he had made no allusion to the fact, that an immense number of notations had been proposed within the last fifty years; and there was a work published, in the form of a report of a society at Zurich—which he had seen continually alluded to in French writings, but the original of which he had not been able

to get a sight of—which described, he understood, about fifty or sixty notations; and within the last ten years nearly as many more had been proposed. He rejoiced to say that no two were alike, and he was always delighted to hear of a new system of musical notation being brought forward, because he felt sure that it added one more to the number of securities which would prevent the present admirable system ever being superseded. Underneath almost all discussions about notation there lay a most serious error, or assumption—namely, that the difficulty lay in the method of representing a certain thing, and not in the thing itself; and even Dr Stainer, quite unintentionally, had been a little unfair in this respect, for he had first spoken of the letter notation and of its simplicity—evidently referring in his mind to psalm-tunes and simple passages for beginners—and then he gave on the blackboard, in the ordinary notation, an example of an exceedingly complicated piece of music. Now, the difficulty in performing such a passage was not in the notation, but in the music itself. Dr. Stainer could sing it, and had sung it; and in his (Mr Hullah's) view, the accidentals marked in the passage tended to remove the difficulty, because they concentrated the attention on the particular places where the modulations occurred. If such a passage were placed before him, the first thing he should look at would be the accidentals, to see if he could get any indication of the key. A person who could sing an interval of a fifth knew something about music, and whether that interval was put before him in one way or another made, as he believed, no difference whatever, as far as the individual interval was concerned; but in the case of complexities, like the example given by Dr Stainer, difficulties must arise in any notation ever seen, they being entirely inseparable from the thing to be represented. He was glad to hear Mr. McNaught say that there were persons who could read four lines of the letter notation at a time, and was, of course, bound to believe that statement, though the fact was quite new to him. With regard to any objections arising from the difficulty of keeping certain things in the mind, there was no art or science whatever which could be practised beyond its very earliest stages without bearing in the mind innumerable facts; and he rejoiced to say that such was the case with music, and he should be very sorry to see (supposing it possible) any system of notation invented which would save those who learnt music the trouble of thinking. He looked upon it as a great educational discipline, that the child had to remember that from E to F was a semitone, whilst F to G was a tone; and, in fact, there was very little more to be remembered. Those who wanted to facilitate the teaching of music, not by sweeping away what was unnecessary, but by leaving out important facts, were doing it the greatest disservice they possibly could.

Mr Sedley Taylor thought Mr Hullah would hardly contend that some of the difficulties which were utterly gratuitous could be any advantage. For instance, suppose a piece of music began

in the key of B, and then modulated into the key of C—then, instead of having the key of C written in its ordinary form, nearly every note in the scale would have an accidental before it, and so what ought to be the simplest thing possible was represented in a very complicated manner. Such gratuitous difficulties could hardly be an advantage. Why should music in the key of C be represented in two totally different manners—one when it began in the key of B, and another when it began in another key? The same passage might thus be represented in eight or ten different ways, according to the key in which the piece of music originally started. The greatest advantage in any notation was that the same things should be represented by the same symbols, but in the established system you might have the same interval represented in half-a-dozen different ways.

Mr. ALEX. S. COOPER said that difficulty might be met by changing the signature.

Mr. SEDLEY TAYLOR said that was not done, as a matter of fact.

Professor MONK said it was done in many instances.

Mr. SEDLEY TAYLOR said he had understood Mr. Hullah to say it would be a disadvantage to get rid of these difficulties.

Mr. HULLAH said he was rather referring to accidentals which did not indicate modulation, but were chromatic. In a long passage, beginning in the key of B, and then going into the key of C, almost immediately—(though that would be rather a curious composition)—there would be no objection to the composer changing the signature.

Mr. G. A. OSBORNE said he should much like to hear an expression of opinion, from the different professors present, on the suggestion put forward by Dr. Stainer, for indicating sharps and flats by the shape of the notes. He had been looking carefully over the specimen, and he did not think the most ordinary persons could possibly make a mistake in reading it. Although it might be the fifty-first system of musical notation, he should be very glad to find both the staff and letter systems superseded by it, for he had never seen anything so perfectly clear and simple. If they studied it for a year, he did not think they could come to any conclusion but that it was a most admirable system.

Mr. MACKESON said reference had been made to the difficulty of teaching by the old notation, but some of those who had a great deal of practice in teaching vocal music by that system had not been able hitherto to discover what those difficulties were. Mr. Hullah said he gloried in the difficulties, such as they were, and if music had not some difficulties to present to the learner, it would be unworthy of study altogether. At the same time he (Mr. Mackeson) thought these difficulties were much overrated—sometimes in the interest of the Tonic Sol-fa system, and sometimes by the natural tendency in the human mind to create difficulties where they did not exist. He had found, in teaching church choirs and choral societies, that what difficulties did

arise were very frequently the result of the teacher's incapacity to explain the subject, and not in the notation itself

The CHAIRMAN, referring to a remark in the early part of Dr Stainer's paper with regard to the representation of speech by written marks, said that was a subject to which he had paid special attention for some years, and he had found insuperable difficulties in the way of representing the intonation of speech It was a very different thing to represent intonation in speech and in music, because in the latter you proceeded by definite intervals, but in speech by glides, and there were a great many sounds which were not musical at all He had found great difficulty in this part of the subject, especially during the last four years, whilst he had been endeavouring to represent the different English dialects, but he found that in almost every county there was a peculiar intonation which characterised its dialect quite as much as the pronunciation of the vowels, but, unfortunately, he was obliged to leave this intonation almost undescribed, through being unable to devise any efficient means of representing it. With regard to the different systems of notation, although he was not acquainted with the fifty mentioned by Mr Hullah, he was rather surprised that no mention had been made of two or three which he had met with for example, in connection with the Letter notation there was a still older one of Rousseau, in which the intervals were represented by figures This was published in 1818, but it had been very much used recently in France It represented the scale by the figures 1 to 7, the sharps having an acute accent through them, and the flats a grave accent, and it was being taught to many thousands in Paris at the present day M. Gallian—who, curiously enough, was a teacher at a deaf-and-dumb school—had also brought forward a system of Staff notation, which was in some respects similar to horn music, because it was always written in the key of C on the staff—the name of the key being indicated at the top.

Mr. HULLAH said that had been published within the last two or three months, as a novelty

The CHAIRMAN said it was described in the book published in 1818. With regard to systems of notation for the equal temperament, about twenty-five years ago Mr Walbridge Lund brought out a system of notation called the 'sequential system,' which had three staff lines and some very queer skeleton-like letters, which troubled the eye very much to read, but it was taken up by several musicians He must say he was rather astounded, knowing Dr Stainer's opinion of the equal temperament, to find the system he had proposed was not strictly applicable to it, because in the equal temperament flats and sharps were the same thing, whereas in the system he had devised $a\sharp$ and $b\flat$ were represented in two different ways, although they represented the same sound on the pianoforte It was not, therefore, adapted to any system of temperament, except those which distinguished sharps and flats, such as the old mean-tone temperament, or the Pythagorean

Dr. STAINER, in reply to the observations which had been made, said he ought, perhaps, to apologise for saying anything about the intonation of the voice in speech, as it was really an unmusical subject, but he did so because he believed a system of notation at one time grew out of it—namely, that of the Hebrew accents, and he therefore mentioned it, as leading up to that subject. With regard to Dr. Stone's observations about the sense of absolute pitch, he had no idea of introducing any physical or metaphysical discussion. You might say this sense was obtained by education, or was innate, or that nobody had it, but the fact remained that certain people existed, who, if they were asked to sound middle C, would always sound it the same pitch within very narrow limits. No doubt if they had lived in Handel's time they would have sounded another pitch, but it was always an absolute pitch to them. With regard to Mr. Bosanquet's system, and that of another gentleman present, Mr. Gill (which was a most ingenious system), he must apologise for not mentioning them and many others, but had he done so he should never have got through his paper, the subject being so enormous that it was impossible to enter into all its branches. Mr. Bosanquet's suggestion, however, reminded him of several efforts which had been made from time to time for altering the position of the keys of the pianoforte, the effect of which would be to save considerable space, namely, by making $f\sharp$ a black key exactly between e and f, and $b\sharp$ a black key exactly between $b\flat$ and c. In short, by giving each semitone the same actual measurement. An octave would then be nearly one inch less in space than now. With regard to Mr. Hullah's remarks about the difficulty being in the music itself, and not in the notation, the fact remained, however you accounted for it, that you could not go into any ordinary choral society without finding that the number of people who could read music was most discreditably small. He honoured the enthusiasm of those teachers who said it was very easy; but still, when you could not walk round any drawing-room and find one person in six who could read music at sight, he thought it was a disgrace to somebody—either the teachers as a body, or their pupils. The only way in which he could look upon it was that the thing itself was difficult.

Mr. HULLAH said, no doubt it was difficult.

Dr. STAINER said, if that were so, he thought they really ought to go through a weeding process in the choral societies, and get rid of those who could not read music. With regard to his own suggestion of notation, no doubt it had been invented long ago, and if it had been, he should be glad, as he could then support it on independent grounds. He was inclined to recommend it, because he thought it would bridge over some of the difficulties which beset the child—namely, those accidentals which Mr. Hullah considered so beneficial.

MAY 8, 1873

JOHN HULLAH, ESQ., VICE-PRESIDENT, IN THE CHAIR

TEMPERAMENT; OR, THE DIVISION OF THE OCTAVE.

By R. H. M. BOSANQUET, M.A., F.R.A.S., F.C.S.,

Fellow of St John's College, Oxford.

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14. Introduction.

In a previous paper read before the Musical Association on November 2, 1874, a method was developed for the derivation and treatment of a class of systems of tuning, to which the term 'regular' was applied—this term being taken to imply that the notes of any such system can be arranged in a continuous series of equal fifths. A notation was described, applicable to written music, by which the position of the notes of such systems in the fundamental series of fifths is defined; and a brief sketch was given of a 'Generalised Keyboard,' founded on a principle of 'symmetrical arrangement,' by means of which the notes of any such system can be controlled, the fingering of any passage being the same in whatever key it is taken.

In the present paper some points of interest in the history of the subject will be first alluded to. The history even of so obscure a subject is very extensive.

In Mr. A. J. Ellis's papers on 'Musical Chords,' and 'On the Temperament of Instruments with Fixed Tones,' in the Proceedings of the Royal Society for 1864, there is a concise account, with references, of the greater part of what is attainable in the history of the derivation of the octave. The points to be now mentioned will be selected with a view to illustrate the development and progress of the subject, and to supplement the information obtainable from Mr. Ellis's papers.

In the discussion of Helmholtz's work, his theory of consonance and dissonance will be examined in some detail, and incidentally the simplest method of computing beats for practical purposes will be introduced. We shall then proceed with the practical application of our systems, and the construction of instruments for their control.

15. Historical.

The practical interest of what remains to us of the theory of the Greek musicians is but small; and it will be convenient to pass it by with the remark that, rightly or wrongly, series of perfect fifths, and the principal derivatives of such a series, bear the name of Pythagoras; the Pythagorean comma being the difference in interval between the extremities of a series of twelve perfect fifths; the Pythagorean, or dissonant third, the third made by four perfect fifths up, and other intervals formed by the notes of such a series bearing analogous names. The approximately true third, however, formed by eight fifths down, has never borne the name of Pythagoras.

16. We pass at once, with this observation, to the beginning of the seventeenth century. The work of Mersenne, bearing the date 1636, affords us information as to the state of the problem at that time.[1]

The portion of Mersenne's work with which we are most directly concerned treats of systems of scales. Almost the whole of these are constructed so as to afford a greater or less number of perfect concords. We select the scale of the key of F, with 18 intervals in the octave. Mersenne dignifies it, and many other of his systems, with the title of 'Systema Perfectum.' We employ the signs in his figure of the keyboard at p. 118. The keyboard is identified as belonging to the scale by the proportional vibration numbers, which are given for each note in both places.

The following is Mersenne's table:—

Systema Perfectum		Positions according to System of Perfect or Approximately Perfect Fifths.
F	5760	*f*
	Semit. majus	
E	5400	╲*e*
	Semit. minus	
× E	5184	╱*e*♭ or ╱*d*♯
	Comma	
× D	5120	*e*♭ or *d*♯
	Semit. majus	
D	4800	╲*d*
	Semit. minus	
× × D	4608	╱*d*♭ or ╱*c*♯
	Diesis	
× C	4500	╲*d*♭ or ╲*c*♯
	Semit. minus	
C	4320	*c*
	Semit. majus	
♮	4050	╲*b*
	Comma	
× ♭ or B	4000	╲╲*b*
	Semit. minus	
B	3840	*b*♭
	Semit. majus	
A	3600	╲*a*
	Semit. minus	
× × A	3456	╱*a*♭ or ╱*g*♯
	Diesis	
× G	3375	╲*a*♭ or ╲*g*♯
	Semit. minus	
·G	3240	*g*
	Comma	
G	3200	╲*g*
	Semit. minus	
× × G	3072	╱*g*♭ or ╱*f*♯
	Diesis	
× F	3000	╲*g*♭ or ╲*f*♯
	Semit. minus	
F	2880	*f*

[1] The works of Salinas and Zarlino, in the 16th century, are not accessible to the writer. Salinas is said to have invented, and Zarlino to have first published, the mean tone system.

For the exhibition of the resources of this system, as regards the chords available, we must refer to the first part of this paper (p 15) We see how limited these resources are, and yet how judiciously the most is made of the limited number of notes provided

The keyboard for this scale is figured at p 118 of the book 'De Instrumentis,' in Mersenne.

All the black keys are doubled, and also the key for the G. Two pairs of black keys are placed one pair on each side of the G key, and three pairs between $b—c$, $c—d$, and $d—e$, respectively, instead of in the usual positions

Mersenne commences his systems with some examples taken from Salinas The first system is one of 25 notes in the octave, which is given in a form precisely analogous to the above; this he calls 'Systema Omnium Perfectissimum.'

This and all other similar systems are on the principle of the addition of more notes, which furnish perfect concords with some of those already present The best-known and most-developed example of this kind in recent times is the enharmonic organ of the late General T Perronet Thompson. The resources of such a system are augmented by the addition of every new note in exactly the same manner. General Thompson employed altogether 40 in the octave It is to be noticed that these are all irregular systems, there is no pretence of aiming at a continuous series of fifths The fifths, being perfect, are of the character of those of positive systems.

Mersenne alludes to negative systems, although none such are fully explained by him He mentions the system produced by dividing the octave into 31 equal intervals He states that it is obtained by dividing the whole tone into five equal parts Now, six major tones exceed an octave by the Pythagorean comma. Hence Mersenne's statement is not true But, if we diminish the value of the major tone in a certain ratio, we can make six tones fall short of the octave by a fifth part of a tone, and then we have $6 \times 5 + 1 = 31$ fifths of a tone in the octave Although the existence of the system was known to Mersenne, and indeed also to Salinas, they both mention it only to state that they regard it as defective, and it was left to Huyghens to recognise its importance Mersenne then mentions the equal temperament of 12 notes very shortly, and also a division of the octave into 24 equal intervals The latter is useless, and he does not appear to have recognised any merit in the former, save its simplicity.

At pages 66, 118, 119, and 129 are given representations of keyboards for systems having various numbers of notes in the octave These are interesting, and some of them are of very great complexity

On page 128 there is a very remarkable table, in which the rules for the dimensions of organ-pipes are set off for a number of different systems. The equal temperament positions are given; and in the third column the positions are given for a system, which is not further explained, but appears to be substantially the old unequal temperament Although this system was certainly

known at the time, it was not apparently as yet in favour with theorists.

17. The next writer worthy of attention is Huyghens. In a tract called 'Cyclus Harmonicus' (Opera Varia, Vol I) he treats of the above-mentioned system of 31. He notices that Salinas and Mersenne had not the knowledge of the methods necessary for its construction, and gives a correct solution by the aid of logarithms. The work appears to have been first published before 1700, but the date of the Opera Varia is 1724.

18. An important work in the history of this subject is 'Smith's Harmonics.' The date of the second edition is 1759. Among the remarks in the preface, a curious one deserves attention, especially as illustrating the mode of thought of practical men at that time. It consists in tempering the major third according to the rule:—

$$\frac{\text{Interval of octave}}{\text{Interval of major third}} = \text{ratio of circumference of circle to diameter.}$$

If we seek to test this we find the proportion:—

$$\frac{12 \text{ semitones}}{3{\cdot}14159} = 3{\cdot}81972 \text{ semitones,}$$

and perfect third $= \underline{3{\cdot}86314}$;

whence the third thus derived is $\cdot04342$ flat.

The properties of the intervals have of course nothing to do with the circle, and the approximate numerical coincidence is merely accidental.

In speaking of the system of mean tones, Smith observes that its characteristic is that all the fifths are one-fourth of a comma flat, for thus the third formed by four fifths is a comma below the Pythagorean third, which is the property of the perfect third He calls it 'the vulgar temperament'; it is the old form of the unequal temperament The object at which he aims in the systems he then proposes is, to get the thirds, fifths, and sixths equally tempered, so that the thirds and sixths may beat as fast as the fifths. From our point of view this is of doubtful correctness We find that fifths are much more sensitive to temperament than thirds, whereas Smith inclines to the opposite view, but eventually adopts the principle that all concords shall be made equally dissonant. This he calls 'equal harmony.'

With reference to the remark made just now, that fifths are more sensitive to temperament than thirds, we must note that the opposite opinion is sometimes expressed Let us, therefore, consider shortly how this stands In the ordinary equal temperament the thirds are sharp by about two-thirds of a comma, and we must admit that this amount of error in the thirds is not readily detected unless the ear be specially attracted to it; for all practical musicians use these intervals constantly without perceiving the dissonance. It is no doubt matter of opinion to some

extent, but the writer's own experience is that fifths which are as much out of tune as two-thirds of a comma are unbearable. The beats in the two cases differ in two ways. Those of the fifth are far more intense than those of the third, since they are derived from an interfering pair of harmonics which lie lower in pitch—namely, the twelfth and octave, and in musical tones these are always more intense than higher harmonics; but these beats are less rapid than those of the third, which are derived from the interference of tierce and double octave. No doubt, therefore, the result depends upon the strength of the various harmonics present, and may vary in different cases.

Smith does not appear to regard positive systems as practicable; on the ordinary keyboard this is undoubtedly true.

Smith gives a general investigation of the properties of negative systems of temperament. His method is interesting, as it furnishes immediately a result which we shall obtain in a different manner. He assumes that the octave is made up of five similar tones and two semitones. We see that this excludes positive systems, with their two classes of tones. He then points out that, since the five tones and two semitones make up an octave, which is a constant quantity, if we suppose the values of the tone and semitone to be changed in any manner, the change of the five tones must be equal and opposite to the change of the two semitones, or the change of the tone is to that of the semitone as 2 : 5. Now in treating negative systems we shall see that all the tones are what we call two-fifths tones, *i.e.* they are got by tuning two fifths up, and both the semitones are five-fifths semitones, *i.e.* are got by tuning five fifths down. Hence the departure from equal temperament of the tone is that of two-fifths up, and of the semitone five fifths down—whence Smith's result follows directly. He examines the systems of 50 and 31 by this method.

Smith gives a very detailed investigation of the theory of beats. This was the most important discussion of the subject up to recent times, and De Morgan commends it highly. The investigations of Helmholtz, however, with the recognition of Ohm's law of simple tones, have disposed of the fundamental principles he employs so far as regards the reception of sound in the ear; and consequently Smith's discussion becomes unimportant for us.

Smith gives a number of rules for determining absolute pitch, or the number of vibrations made in a given time by any note. The first of these depends on the mechanical properties of the monochord, the rest on the observation of beats. None of them are of practical value now, as they do not admit of being performed with sufficient accuracy for our purposes.

As Smith's systems led to a very unequal temperament, they are valueless, practically, without additional notes to the keyboard. His direction for ordinary keyboards is as follows:—

'Till instruments are made with a changeable scale, it is

more proper to tune the defective scale in common use by making every fifth and third to the same base beat equally quick—the former flat, and the latter sharp.'

This system is intermediate between the old unequal temperament, or system of mean tones, and the ordinary equal temperament. It is an improvement on the former. The more recent form of the unequal temperament is roughly Smith's system. (See Hopkins on the Organ, p. 183.) Smith describes (p. 177) an arrangement for introducing additional notes into the harpsichord, to be substituted for the normal notes on certain keys by the action of drawstops. There is an organ in a private house in Edinburgh which possesses a similar arrangement. In both cases the notes are intended to constitute a regular negative system, either the old unequal temperament (mean-tone system) or an approximation to it. The action of the stops was to vary the portion of the circle of fifths presented on the keyboard. Thus the following arrangements might be accessible with two drawstops, the one extending the resources of flat keys, the other those of sharp keys:—

Flats: *b–e–a–d–g–c–f–b♭–e♭–a♭–d♭–g♭*
Ordinary arrangement: *g♯–c♯–f♯–b–e–a–d–g–c–f–b♭–e♭*
Sharps: *e♯–a♯–d♯–g♯–c♯–f♯–b–e–a–d–g–c*

Mr. A. J. Ellis has recently caused to be constructed a harmonium in which this principle is further developed. (See Proceedings of the Royal Society, 1874.) The writer's opinion is, that any procedure which involves the use of mechanism, whether stop-handles or pedals, for the selection of the notes required, is unpractical.

There is an interesting passage in which Smith anticipated to some extent the doctrine of Helmholtz, that dissonance consists of beats, or intermissions more or less rapid in the continuity of the musical tone. He says, at p. 227, using expressions almost identical with those of Helmholtz:—'For nothing gives greater offence to the hearer, though ignorant of the cause of it, than those rapid rattling beats of high and loud sounds, which make imperfect consonances with one another; and yet a few slow beats, like the slow undulations of a close shake now and then introduced, are far from being disagreeable.'

19. An important tract is Woolhouse's 'Essay on Musical Intervals' (1835). This writer employs, in the first instance, equal temperament semitones, which he calls mean semitones, as his unit of interval; but subsequently abandons the method for another, which we now judge to be of less utility. Woolhouse gives numerical values of the principal intervals in E. T. semitones to twelve places; these agree, as far as they go, with the twenty-place values given in the first part of this paper.

The solution of the general problem given by Woolhouse is chiefly interesting on account of the principles employed in the actual computation. In the result, he divides the octave into fifty equal intervals, and employs only a certain number of these

to construct scales. He provides a considerable number of scales, but, in consequence of the omission of many notes of the system, these do not fulfil the important conditions of a regular system, still less those of a regular cyclical system. The distinction between the sharp of a note and the flat of the note above it is retained and made essential. We have seen that this form of notation can only be employed in negative systems.

Woolhouse then (p. 49) treats the Huyghenian division of 31 in the same way, and finishes by dividing the octave into 19 equal intervals. The resulting concords would be bad, and the sequences of melody also. This system is negative, and of the first order.

Woolhouse's explanation of the 'terzo suono,' sometimes called Tartini's tone, is erroneous, as are all explanations before that of Helmholtz; otherwise, as a treatise on musical mathematics, this tract is of great excellence; it deserves to be read still as a model of elementary exposition.

20. A system was proposed by Earl Stanhope, of which the scale is substantially as follows: *c–g–d–\a–\b–f♯–/g♭–/d♭–/a♭–/e♭–b♭–f–c*. Its capabilities are more limited than those of any of the scales of Mersenne.

21. A paper by De Morgan, 'On the Beats of Imperfect Consonances' (Cam. Phil. Trans. Vol. X. p. 129), contains some reference to our subject. He employs equal temperament semitones as the unit of interval, and gives rules for the transformation of logarithms of vibration ratios into terms of equal temperament semitones and *vice versâ*, identical in principle with those in the writer's previous paper.

The rest of De Morgan's paper is foreign to the present subject; but we may remark that his treatment of the problem of beats belongs to the period which preceded Helmholtz's investigations.

22. A paper by Herschel (Quarterly Journal of Science, Vol. V., p. 338) proposes various scales. In one of these, which is preferred, all the fifths except one are perfect, the remaining one erring of course by a Pythagorean comma. His observation is, 'The chief blemish is the paucity of perfect thirds of both kinds, but, on the other hand, none of them err in excess or defect beyond a comma.'

The defective fifth is taken to be *d—\a* (table at top of p. 348, column D, and row Sol). Now an error of a comma in a fifth makes it unfit for use in music; no ear can tolerate a fifth which is a comma out of tune. So that this arrangement would exclude from use the keys of G major, D major, and A major, to say nothing of minor keys.

23. A considerable work has been carried out by Mr. H. W. Poole; his last paper is in 'Silliman's American Journal,' Vol. XLIV., July 1867, p. 1. It is difficult to convey a good idea of the details of the keyboard he there proposes. But the general principle is as follows:—

There are five distinct series of notes, each proceeding by

successive fifths. These are:—(1) keynotes, (2) thirds, (3) sevenths, (4) thirds to (2) for the minor keys, (5) sevenths to (2) for the minor keys.

The keynotes in each key are those which form perfect fifths derived from the tonic. Thus, in the key of C, we have *f—c—g—d*. The arrangement of the notes of this series is fundamental, and all the others are placed with reference to them.

These so-called keynotes are, in fact, placed according to the writer's principle of 'symmetrical arrangement.' This is, however, applied only to the 'keynotes,' and the remaining notes of each scale are introduced as auxiliaries. The relative displacements of the keynotes from the horizontal are much greater than in the writer's keyboard—three times as large. It may be as well to mention that the writer's invention of this arrangement was entirely independent of Mr. Poole's.

As far as can be judged from the description, the uniform scale of Mr Poole's keyboard must be rather like that of A major on the ordinary keyboard. But the number of auxiliaries is considerable, and must lead to constant modification of the principal form of scale.

The writer judges the distinction of the five series to be unnecessary and cumbrous, as there exist regular systems which afford approximations sufficiently close to make one series of fifths serve for all purposes. Moreover, even the scale of 19 notes of Mersenne provides notes omitted in this arrangement—viz. the notes to which the keynotes are thirds. Mr Poole has indeed indicated where they may be placed as auxiliaries, but they cannot be used as keynotes. The chief objection to this form of keyboard consists in the difficulty which arises from the difference in the arrangement of the auxiliary notes and the so-called keynotes. The player may want to make any note on the instrument a keynote, or to take it in any other form at a moment's notice; and this can only be accomplished perfectly by a keyboard which is symmetrical in the arrangement of all the notes it governs.

24. General T. Perronet Thompson constructed an enharmonic organ in which a number of notes belonging to the positive system of perfect thirds were commanded by three keyboards of great complexity. On each of these keyboards a scale of the ordinary keyboard is the basis of operations. A certain number of auxiliary keys are then introduced on each board, for the performance of keys related to the principal key of the board. These are introduced in a number of different forms, wherever they are wanted. The result is a complication of scales for a considerable number of different keys, compared to which the twelve scales of the ordinary keyboard are simplicity itself.

A symmetrical arrangement of the notes of this instrument was given at p. 16 of the first part of this paper.

Notwithstanding the complexity of the keyboards, performers appear to have been tolerably successful with this instrument

In General Thompson's tract on 'Just Intonation,' the principal practical point treated of is the double second of the key. It is easy to see that the second which forms a perfect fifth to the dominant (as D in the key of C) cannot be a perfect fifth to the sixth of the key (A, determined as a perfect third to F), but we require another note, D, a comma flatter than D, to perform this function.

General Thompson employed the notation of the system of 53 in his calculations. He appears to have been aware that his system was really different, and he employed the notation of the system of 53 always within such limits as prevented the occurrence of any error in practice.

General Thompson's account of the way in which he employed the monochord is well worth attention; to vary the pitch he varied the weight by which the string was stretched, as well as the length of the string. His form of the instrument is probably the most perfect ever constructed.

25. We now come to Helmholtz. While there is in his writings but little that is strictly new on the division of the octave, he has yet so entirely revolutionised the theory of consonance and dissonance, that the modern point of view of the whole subject probably owes more to him than to any other single individual.

The theorem of the approximate identity of the major third given by eight downward steps in a perfect series of fifths and the perfect major third is given by Helmholtz; he also considers the plan of making the third perfect and of supposing the minute error that results to be distributed uniformly among the fifths, thus forming the positive system of perfect thirds. He ascribes the first knowledge of this approximate representation of the third to the Persians, on the authority of a division of the monochord recorded in one of their ancient musical treatises.

Helmholtz constructed a harmonium in which twenty-four tones to the octave were distributed between two ordinary manuals. The tones were intended to form a portion of a regular positive system of perfect thirds, but according to the rules given for the tuning the result would not be quite regular. The instrument was available for experiment, but to a very small extent only for practical purposes.

In the Seventeenth Appendix (ed. 3) there is given a plan for arranging a system of the same kind on one manual, with change-pedals or other accessory mechanism, by which the manual could be put in tune in any key that is desired. The writer, however, judges this and all similar systems to be essentially defective, especially when applied to positive systems.

Helmholtz's notation [1] is not identical with that adopted in this paper. The necessity for change arose in the first instance from the impossibility of using Helmholtz's notation in written music.

[1] This notation refers primarily to perfect fifths and thirds; its development is due to Von Oettingen. Page 438, 3rd edit.

But Helmholtz's great work is the physical theory of consonance and dissonance established by him, founded on his theory of the reception of musical sounds in the ear. It is necessary here to enter into the subject to some extent to introduce the simplified forms of computation of beats which follow, and more especially as there appears to have been some oversight in the exposition of an important portion of Helmholtz's theory of hearing in the most important recent popular work on the subject.

Every musical note may be regarded as the sum of a series of simple tones, consisting of pendulum oscillations, whose vibration numbers are multiples of that of the fundamental.

When any complex system of simple tones falls on a continuous resonant scale, such as is approximately furnished by a harp, each simple tone seeks out and impresses itself upon that portion of the scale which agrees with it in pitch, and affects also the regions immediately adjoining to a greater or less extent; but beyond a certain small region surrounding the point of corresponding pitch, a simple tone does not affect the resonant scale.

In the ear a resonant scale of this description is believed to exist, and on this theory simple tones of different pitch impress themselves on different portions of the nervous organisation of the ear.

No sensible beats can be produced in the ear by interference of fundamentals separated by intervals greater than a minor third. (This limiting interval varies slightly towards both the extreme portions of the scale.) This point cannot be too strongly insisted upon. It is the basis of Helmholtz's theory; and we must digress for a moment to comment on an oversight in an exposition of the subject by a high authority.

26. In 'Tyndall on Sound' (2nd ed. p. 296) we find the following statement as the reason why no beats are audible in the octave C_1—C_2:—

'Here our rates of vibration are 512—256; difference=256.'

'It is plain that in this case we can have no beats, the difference being too high to admit of them.'

The reason, then, is here said to be that the beats are more rapid than 132 per second, which is supposed to be the limit of them.

This is, however, not Helmholtz's position. Helmholtz's theory is that notes an octave apart affect different portions of the nervous mechanism of the ear, and consequently no beats ever take place between these sounds at all when they are received in the ear.

Attention was directed to this passage by a recent paper of Professor Mayer, of New York ('American Journal of Science,' October 1874). He does not clearly point out that the above passage departs from Helmholtz's theory, but he sees that it is wrong, and accounts for it by a new and most valuable portion of the theory, which he for the first time presents in the above paper.

The following passage from Mayer's paper puts the point clearly:—

'But if Professor Tyndall had taken, in place of the above

forks, two forks giving 40 and 80 vibrations per second, he would, according to his premisses, have made this octave a most dissonant interval; for would he not have had (80—40=40) forty beats per second entering his ear? Similarly, if we assume that 33 beats per second always produce the maximum dissonance, then even the interval $C_1 \cdot C_2'$—in our notation, C—*c*

—'which gives a difference of 64, is far removed from consonance.'

Mayer accounts for the difficulty by his experiments on the limits of rapidity of audible beats in different parts of the scale, which give interesting results, and complete by experimental evidence a portion of the theory, the nature of which Helmholtz had indicated only in a general manner.[1]

We cannot here enter into the details of Dr. Mayer's paper, but we must note that the numbers given furnish an actual demonstration of Helmholtz's hypothesis of the analysis of tones in the ear. Again, Helmholtz does not say, as Tyndall makes him, that beats blend always into a continuous sound when they attain the limit of 132 per second. He says (3rd ed. p. 270) of the 132 beats per second, produced by the interval b_3 c_4, 'and these are really audible, in the same manner as the 33 beats of b_1 c_2, although they sound somewhat weaker in the higher position.'

For Helmholtz's exposition of his theory we may refer to p. 271. He there points out, that if the offensiveness of beats depended on their number alone, the semitone b_1 c_2 would be as dissonant as the fifth C G, both intervals giving in air 33 beats per second; and he proceeds (p. 272) to account for this by the assumption of a law for the sympathy of the organ of Corti, according to which the intensity of the interference of fundamentals is about $\frac{1}{2}$ of the maximum for the minor third, $\frac{1}{10}$ for the major third, and insensible for all greater intervals.

It is to be noted that in the third edition Helmholtz abandons the theory that the organ of Corti is the mechanism of reception, and transfers this to the membrana basilaris, the theory of which is given in Appendix XI. In a paragraph on p. 230, Helmholtz points out that he has not altered his phraseology throughout the book, but desires it to be understood that he considers the resonance of the organ of Corti to be only such as it receives from its connection with the membrana basilaris. To return to our sketch of Helmholtz's principles.

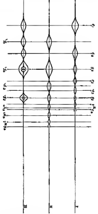
27. The beats of imperfectly-tuned consonances greater than the minor third are, in general, produced either—

(1) By the interference of harmonics present in the two notes, in pairs nearly corresponding in pitch. Or—

[1] Compare 'Philosophical Magazine,' Vol. XLIX., p. 352.

(2) By the interference of difference tones (Tartini tones) with each other, or with harmonics, in pairs nearly corresponding in pitch.

The following figure illustrates the mode of production of the beats of a fifth about a comma out of tune, by interference of harmonics, difference tones being disregarded.—



The horizontal lines are supposed to be made up of resonant

points, vibrating in vertical lines. We may suppose the horizontal line to be a section of a sheet of wires standing at right angles to the paper, and somewhat similar to the sheet of wires which exists in the pianoforte.

The first figure shows the way in which a musical note is decomposed into simple tones of the harmonic series when received on an instrument of this kind. The second figure is similar, but placed about a fifth higher; while the third figure represents the combination of the two, it being supposed that the fifth is about a comma flat. The loops on the horizontal lines indicate the limits between which the points on that line may be supposed to vibrate.

The bearing of this theory on the deviation of elementary concords is obvious, but it is impossible to dwell on it here. We must only say that it differs entirely from the mode of derivation from harmonic series initiated by Dr. Day, both in that it refers the question of consonance and dissonance to a physical cause, viz., the production of beats, and also in that it takes account of the series of harmonics which exists in each note of the combination. We may refer for one moment to the explanation of the interval of the fourth as tuned free from beats, which is a crucial instance of the difference between the two points of view. If the fourth be g_0—c_1  the double octave of g_0 and the twelfth of c_1 will both fall on g_2; and if the two notes are not exactly in tune, beats will arise on that note exactly as shown in the above figure. So long as, according to Dr. Day's view, the harmonics of the lower note are alone regarded, it is impossible to assign any physical cause for the beats which arise when this interval is imperfect, as also to refer the fourth to any analogy or rule whatever; as there is no such interval as the fourth in the harmonic series, and the mere name, inversion of the fifth, conveys no explanation.

The problem is thus reduced to the interference of two sounds near each other in pitch. The beats of the lowest pair of harmonics, which approximately coincide, are always so much the strongest that we may neglect the others.

In applying these principles to the case of any imperfect concord, we notice that, if two notes are sounded together such that the vibrations numbers of the fundamentals are nearly in the ratio $p:q$, then the lowest pair of interfering harmonics will be the harmonic of the qth order in the first note, and the harmonic of the pth order in the second. It must be understood that the *order* of a harmonic is denoted by its vibrations ratio to the fundamental.

Thus in the above case of an imperfect fifth, where the fundamentals are nearly as 2 : 3, the twelfth, or harmonic of the third order of the first note, interferes with the octave, or harmonic of the second order, of the second; and in the case of the fourth

(3 : 4), the double octave, or harmonic of the fourth order, of the first note interferes with the twelfth, or harmonic of the third order, of the second This is obvious when realised, but it often saves trouble to note the rule. The number of beats given by two interfering notes is, of course, the difference of their vibration numbers

As an example, let us determine the number of beats per second in the equal temperament fifth c_1,—g_1, (c_1=256.) The perfect fifth being 7 01955000 semitones, the g_1, and therefore, also, its octave g_2, is ·0195500 flat. Applying rule 2, paragraph 2, we find the logarithm of the vibrations ratio of this interval.—

·0195500
0000652 = $\frac{1}{308}$
19 = $\frac{1}{10000}$

40) ·0196171

0004904 = log. ratio required (flattening of tempered fifth).
c_1 has 256, and g_2 has three times as many vibrations.

2·8853613 = log. 768 000 (g_2)
Log. ratio ·0004904

2·8848709 = log. 767·133 (tempered g_2)

diff. = ·867 number of beats per second.
60

52·04 number of beats per minute.

For the theory of difference of tones we must refer to Helmholtz We shall here accept the law that the vibrations number of the difference tone is the difference of those of its primaries.

Example.—To find, the number of beats per second of the difference tones of c_1-e_1, e_1-g_1, in the equal temperament triad

From the above example we have $c_1 = 256$, $g_1 = \frac{767{\cdot}133}{2}$ $= 383\ 566$ We have for the ratio $c-e$ (paragraph 2)

log ratio = 1003433
and log 256 = 2 4082400

2·5085833 = log. 322·540
322 540
256

difference $e-c$ 66·540 383.566
61 026 322 540

beats per second 5·514 61.026 difference $g-e$.

Hence these difference tones give about $5\frac{1}{2}$ beats per second In cases where the difference tones are strong, these beats, or the

displacements of the difference tones, where beats are not produced, are the most disagreeable effects of the equal temperament. If the chord were in perfect tune the two difference tones would coincide, both having the vibrations number 64.

Distinction between beating dissonances and unsatisfied combinations.

We have so far assumed, with Helmholtz, that dissonance is entirely due to the presence of audible beats. Now, consider two notes separated by the interval of the harmonic seventh; these may be represented very nearly by $c - \backslash b\flat$. When the interval is exact, beats cease entirely, and we cannot say that any dissonance, in the ordinary sense of the term, is present. We might call such combinations as this '*unsatisfied combinations*,' as distinguished from dissonances. The fourth may also be regarded as an unsatisfied combination. The weight of authority in technical music is, however, so greatly in favour of regarding such combinations as dissonances, that it appears to be necessary to comprise under the general head of dissonances both beating dissonances and unsatisfied combinations.

28. There remains to be noticed, last but not least, the series of papers by Mr. Alexander Ellis, F.R.S., in the Proceedings of the Royal Society for 1864, to which allusion has been already made, and especially the paper at p. 404, 'On the Temperament of Musical Instruments with Fixed Tones.' This paper contains a mass of valuable information on our subject. The various systems are treated according to a system of formulæ, with the object of comparing their excellence in various respects, and the results are tabulated. One point is especially worthy of attention—viz., the treatment of variations in the melodic sequences of the different systems. It is assumed (*l.c.*) that the sequences of the diatonic scale are the best, and that in proportion as the sequences of any other scale differ from those of the diatonic scale, they will offend the ear. Now this is a most important point in the theory of temperament, and one which has not received sufficient attention in general.

In support of Mr. Ellis's view, we might refer to an experiment conducted by Helmholtz and Herr Joachim, with the assistance of Helmholtz's harmonium with pure scales, which was mentioned above. The result appeared to prove conclusively that the eminent violinist employed pure scales. It may be inferred from this that the sequences of the diatonic scale would commend themselves naturally to the ear; on the other hand, this may be explained by the fact that some violinists learn their stopping by practising thirds; of course, if they play so as to get the thirds and fifths perfect, they would play substantially diatonic scales.

The writer believes, on the contrary, that the preference of certain melodic sequences by the ear is entirely a matter of education and custom. There can be no doubt that nations exist, whose tunes contain sequences which may be called quarter-tones, entirely foreign to all our ideas of music. The Egyptian Arabs

are mentioned as an instance. The writer's experience with the enharmonic harmonium, on which all manner of scales producible from regular systems with practically perfect fifths can be performed, leads to the belief that, generally, to highly educated ears, the uneven sequences of the diatonic scale are disagreeable. This may be attributed to the adoption of the tempered scale as a standard, through custom. Those notes which deviate widely from the tempered scale—as, for instance, the approximate harmonic sevenths—however smooth the chords, are always found disagreeable by listeners of this class. The true minor third in the minor scale is often objected to also, as too high in pitch; it deviates very widely from the tempered note. The writer is therefore disposed, for the present, at all events, to accept the equal temperament as a better standard for melodic sequences than the diatonic scale.[1] Experimentally, indeed, it appears that the sequences of the Pythagorean scale, with dissonant thirds, are pleasanter than either, so long as harmony is kept out of the way. As the result of this discussion, we banish all consideration of melodic sequences from our theory, as an element of preference between systems, believing that the appreciation of any sequences whatever is possible with custom. As the result of his whole discussion, Mr. Ellis gives the preference to the mean-tone system, which is substantially a regular extension of the old unequal temperament, and he proposes a keyboard for its control, derived from the ordinary keyboard by the introduction of additional notes.

Another discussion of the properties of certain systems by Mr Ellis will be found in the Proceedings of the Royal Society for 1874.

[1] The opinion above expressed, that equal temperament is the best melodic standard at present, owing to the education of musicians in that system, received remarkable confirmation at the reading of this paper. As will be mentioned later, both the just and mean-tone systems were illustrated by actual performance, and amongst numerous remarks of a similar kind, the following is perhaps the best illustration. The 23rd prelude of Bach's 48 being performed in the mean-tone system, the semitone d♯–e was objected to by eminent musicians present. Now this semitone is, theoretically, 1·171, or very nearly $1\frac{1}{6}$ of an E.T. semitone. The just semitone (difference between perfect third and fourth) is 1,117, or between $1\frac{1}{9}$ and $1\frac{1}{8}$. Hence the mean-tone semitone is nearer to the just semitone than is the E.T. semitone. If, therefore, the diatonic scale were the true standard of melody, the mean-tone semitone should be a little better than the E.T., which would be contrary to the above observation. Again, as to the effect of education. There can be no doubt that in Handel's time all organs in England and most elsewhere, were tuned to the mean-tone system. Bach abolished this system in Germany, and it has nearly disappeared in England. But there is no doubt that the scales of that system, which afforded good chords, were always looked upon as the best attainable in any manner, the 'wolf' due to the limited number of notes being the sole reason for discarding the system. Consequently, the semitone now objected to must formerly have been very generally received as the correct semitone. If musical education in theory were so conducted that the sounds of harmonics, intervals, &c. were studied, as well as numbers and names which have no musical value when taken alone, it might be expected that the practical objection to these intervals, which arises from the exclusive study of equal temperament, would disappear.

29. Scales.

We have seen that the intervals of regular systems are to be regarded as formed by successions of fifths. We have, therefore, only to determine the departure of the fifths of any system from equal temperament, and the number of fifths by which we proceed from the keynote to any given note of the scale, we then know at once the interval which any such note makes with the keynote.

30. Positive Systems.

Second of the Key.—In any positive system the second of the key may be derived in two ways: first, as a fifth to the dominant, in which case the derivation is by two fifths up from the keynote; and, secondly, as a major sixth to the subdominant, in which case the derivation is by ten fifths down from the keynote. Thus, the first second to *c* is *d*; the other, ↘*d*. On account of the importance of this double form of second, we will consider the derivation of these two forms by means of the ordinary ratios, in the case, namely, in which perfect intervals are employed.

First, two fifths up and an octave down give $\left(\frac{3}{2}\right)^2 \times \frac{1}{2} = \frac{9}{8}$, when the fifths are perfect

Secondly, one fifth down gives the subdominant (*c–f*), and a sixth up gives the depressed second (↘*d*), or $\frac{2}{3} \times \frac{5}{3} = \frac{10}{9}$, which is the ratio of ↘*d* to the keynote, when the fifths and thirds are perfect.

The ratio of *d* : ↘*d* is then $\frac{9}{8} \div \frac{10}{9} = \frac{81}{80}$, which is an ordinary comma.

We must remember that our systems only give approximations to this result, but the best of these approximations are very close.

In the harmonium, with the system of 53—which may be regarded for practical purposes as having perfect fifths, and very nearly perfect thirds—the exchange of *d* for ↘*d* in the chord *f*–↘*a*–↘*d*, or even in the bare sixth, *f*–↘*d*, produces an effect of dissonance intolerable to any ear.

Minor Third.—The minor third is not an interval which is very strictly defined by beats. In chords formed of successions of minor thirds, almost any form of the interval may be employed; and, as a matter of fact, the minor third which comes below the harmonic seventh in the series of harmonics (7 : 6), is one of the smoothest forms of this interval. *c*–↘*e*♭ is an approximation to such a chord, where the ↘*e*♭ is derived by fifteen fifths down. But in minor common chords the condition is that the major third or sixth involved shall be approximately

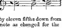
perfect, and this gives the triad *c*–↗*e*♭–*g* where the ↗*e*♭ is derived by nine fifths up. The intermediate form, *e*♭, gives a minor third not quite so smooth as either of the other two, but it is capable of being usefully employed in such combinations as the diminished seventh, and it is preferred by many listeners, as deviating less from the ordinary equal temperament note, from which it has only the departure due to three fifths down. The interval between the harmonic seventh on the dominant and the minor third of the elevated form on the keynote, is the smallest value of the whole tone which occurs, the departure from E. T. of such a tone being due to twenty-two fifths, or about two commas; and although two chords, involving these notes in succession, may each be perfectly harmonious, the sequence is generally offensive to ears accustomed to the equal temperament. Example:—

Custom makes such passages sound effective, especially when the succession is slow enough to enable the ear to realise the fineness of the chords.

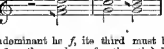
Major Third.—This interval has been already discussed; the note taken is that formed by eight fifths down.

Fourths and *Fifths* need no remark.

Depressed Form of the Dominant.—When the dominant is used in such a combination as the following:—



it must be formed by eleven fifths down from the keynote, unless we regard the keynote as changed for the moment, in which case, by elevating the subdominant, we may retain the fifth in its normal position. The most judicious course depends on whether the fifth is suspended or not. Thus, if the fifth is suspended, we may write:—



For if the subdominant be *f*, its third must be ↘*a*, and its sixth must be ↘*d*; *g* then makes a fourth with ↘*d*, which is unbearable to the ear; the fourth must be made correct, and the

ways of doing so are shown above The difficulty may be otherwise got over by writing the passage :—


&c.

Minor Sixth.—This interval is pretty sharply defined The usual form is ↗a♭, which is got by eight fifths up ; the keynote forms an approximately perfect third with this note by inversion.

Major Sixth (c–↘a) —This interval is, as a matter of fact, more sharply defined than one would expect on a first consideration, but we immediately see the reason Regarded as an inversion of the minor third (6 : 5), it has the ratio (3 : 5), and therefore arises by the interference of the fifth harmonic (tierce) of the lower note with the third (twelfth) of the upper. If c_1 be the lower note, the interference is then on e_3, and the total intensity of the harmonics concerned (3 and 5) is greater than that of the pair (4 and 5) which determine the major third This interval, then, must be kept strictly to its best value. The ↘a is got by nine fifths down.

In chords formed of a succession of minor thirds, major sixths frequently occur. Care must be taken to dispose them so as to make this interval correct If a deviation is necessary, it is better, if possible, to extend the interval by an octave, the resulting major thirteenth (3 : 10) is not very sensitive.

Minor Seventh.—There are three forms of the minor seventh. To fundamental *c* these are ↗b♭, b♭, and ↘b♭ :—

↗b♭ , ten fifths up , the minor third to the dominant.
b♭ ; two fifths down ; the fourth to the subdominant
↘b♭ ; fourteen fifths down , approximation to the harmonic or natural seventh.

The two first speak for themselves.

If we compute (Rule 1, paragraph 2) the departure of the harmonic seventh (7 : 4), we find that it falls short of ten semitones by 31174, or (as we phrase it) the departure is — 31174, or about one-third of an E T. semitone In fact, it is well known that, if we flatten a minor seventh by some such quantity, we can obtain a smooth combination, free from beats Now the departure of fourteen perfect fifths down is 14 × ·01955 = — ·27370 ; and a note having this departure differs from the natural seventh only by 03804, or less than the twenty-fifth part of a semitone. Helmholtz pointed out this approximation for the first time, as far as the writer is aware

Rule.—The natural or harmonic seventh on the dominant must not be suspended, so as to form a fourth with the keynote.

For the harmonic seventh to dominant *g* is ↘f, and c–↘f forms a fourth a comma flat, approximately In ratios this stands as follows . the ratio of tonic to dominant is 4 : 3 , dominant to

its harmonic seventh, 4 : 7; whence ratio of harmonic seventh of dominant to tonic is 21 · 16, or 63 · 48. But ratio of fourth to tonic is 4 · 3, or 64 · 48, whence this fourth differs from the harmonic seventh to dominant in the ratio 64 : 63, or by more than a comma.

Major Seventh.—There is only one form of major seventh which can be used in harmony, viz., ↘*b*, this note is got by seven fifths down, it forms a major third to the dominant. In unaccompanied melody the form *b* produces a good effect. This is got by five fifths up with perfect fifths. It forms a dissonant, or Pythagorean third, to the dominant. The resulting semitone is less than the E. T. semitone by nearly $\frac{1}{10}$ of a semitone.

31. Negative Systems.

Second of the Key.—Two fifths up. The double form does not appear.

Minor Third.—Three fifths down.

Major Third.—Four fifths up.

Fourth.—One fifth down.

Fifth.—One fifth up.

Minor Sixth.—Four fifths down.

Major Sixth.—Three fifths up.

Minor Seventh.—Here we have the only case of a double form. *b*♭, two fifths down, makes a fourth to the subdominant, and ↗*b*♭, ten fifths up, gives the approximate harmonic seventh. This approximation is very close in the best negative systems. Thus, in the negative system of perfect thirds, where −·13686 is the departure of four fifths up, the departure of ↗*b*♭ is $-\frac{10}{4} \times {\cdot}13686 = -{\cdot}34215$, which exceeds the departure required (−·31174) by ·03041, or about $\frac{1}{33}$ of a semitone. The rule about not suspending the dominant harmonic seventh into a tonic fourth holds also in these cases.

Major Seventh.—Five fifths up.

In negative systems the notation marks are commonly omitted. But as the harmonic seventh would thus be written *a*♯, they must be introduced for this or any similar purpose.

As the writer has not yet had in his hands for study an example of a negative system, he is not able to speak of these with the same experience as of positive systems.

32. Number of Units in the Intervals of the Scale.

In Regular Cyclical Systems, to find the number of units in any interval in the scale. Let x be the number of units in the seven-fifths semitone.

$$\text{Then } x\frac{12}{n} = 1 + 7\delta = 1 + 7\frac{r}{n}$$

$$\text{or } x = \frac{n + 7r}{12}$$

It is easy to see that x will always be integral, if the order condition is satisfied (Theorem III)—viz, if $7n + r$ is a multiple of 12.

For then, $7(7n + r) = 49n + 7r$, whence, casting out $48n$, $n + 7r$ is a multiple of 12. We can now determine the remaining intervals in terms of x and r:—

In the system of 53, $x = 5 \quad r = 1$
In the system of 31, $x = 2 \quad r = -1$

The following table gives the general expressions for positive and negative systems, and the numbers for the systems of 53 and 31:—

Number of Units.

Interval.	Positive Systems.	System of 53	Negative Systems.	System of 31.
5-fifths semitone	$x - r$	4	$x - r$	3
Minor tone / 10-fifths tone	$2x - 2r$	8		
Major tone / 2-fifths tone	$2x - r$	9	$2x - r$	5
Minor third	$3x - r$	14	$3x - 2r$	9
Major third	$4x - 3r$	17	$4x - 2r$	10
Fourth	$5x - 3r$	22	$5x - 3r$	13
Fifth	$7x - 4r$	31	$7x - 4r$	18
Minor Sixth	$8x - 4r$	36	$8x - 5r$	21
Major Sixth	$9x - 6r$	39	$9x - 5r$	23
Harmonic Seventh	$10x - 7r$	43	$10x - 5r$	25
Minor Seventh	$10x - 6r$	44	$10x - 6r$	26
Major Seventh	$11x - 7r$	48	$11x - 6r$	28
Octave	$12x - 7r$	53	$12x - 7r$	31

The $-r$'s in negative systems are, of course, positive quantities.

33. Concords of Regular and Regular Cyclical Systems.

The theory which has been established permits us to calculate the departures and errors of concords in the various Regular and Regular Cyclical Systems.

There is another quantity which may be also conveniently taken into consideration in all cases—viz, the departure of 12 fifths of the system. We will call this Δ, putting $\Delta = 12\delta$ where δ is the departure of one fifth.

We have then the following table of the characteristic quantities for the more important systems hitherto known. The value of the ordinary comma $(\frac{81}{80})$ is 21506. It is comparable with the values of Δ, and if introduced in its place in the table would give rise to a regular non-cyclical system, lying between the system of

53 and the positive system of perfect thirds, the condition of which would be that the departure of 12 fifths = a comma.

Name or n	Order r	$\Delta = 12\delta$ or $12\frac{r}{n}$	Error of Fifth $\delta - 01955$	Error of Third $13686 - 4\delta$	Error of Harmonic Seventh $31174 - 14\delta$
17	1	70588	03927	−·33373	−·51178
29	1	41379	01493	− 27586	− 17101
41	1	29268	00484	− 13512	− 02970
Perfect Fifths	—	23460	—	− 01354	03804
53	1	22642	− 00068	−·01408	·04758
Positive Perfect Thirds	—	20523	− 00244	—	·07223
118	2	20339	− 00280	00127	07445
65	1	18462	− 00417	01378	09635
($\delta - \frac{r}{n}$ is here negative)				$13686 + 4\delta$	$31174 + 10\delta$
43	−1	− 27907	− 04431	03784	·06418
31	−1	− 38710	− 05181	00783	− 01084
Mean Tone Negative Perfect Thirds	—	− 41058	− 05378	—	− 03041
50	−2	− 48000	− 05958	−·02314	−·08828
19	− 1	− 63158	− 07218	−·05387	− 21458

Supplementary Table, exhibiting the Derivation of the Departures of Fifths and Thirds from Equal Temperament, in Terms of Equal Temperament Semitones :—

Name or n	Order r	Departure of Fifth = δ	Departure of Third
17	1	$\frac{1}{17}$	$-\frac{4}{17}$
29	1	$\frac{1}{29}$	$-\frac{4}{29}$
41	1	$\frac{1}{41}$	$-\frac{4}{41}$
Perfect Fifths	—	$\frac{1}{51 \cdot 151}$	$-\frac{4}{51 \cdot 151}$
53	1	$\frac{1}{53}$	$-\frac{4}{53}$
Positive Perfect Thirds	—	$\frac{1}{58 \cdot 464}$	$-\frac{4}{58 \cdot 464}$
118	2	$\frac{1}{59}$	$-\frac{4}{59}$
65	1	$\frac{1}{65}$	$-\frac{4}{65}$
43	1	$-\frac{1}{43}$	$-\frac{4}{43}$
31	−1	$-\frac{1}{31}$	$-\frac{4}{31}$
Mean Tone Negative Perfect Thirds	—	$-\frac{1}{29 \cdot 237}$	$-\frac{4}{29 \cdot 237}$
50	−2	$-\frac{1}{25}$	$-\frac{4}{25}$
19	−1	$-\frac{1}{19}$	$-\frac{4}{19}$

34. Application of the Principle of Symmetrical Arrangement to Positive Systems

This has been sufficiently illustrated by the symmetrical arrangement of the notes of General Thompson's enharmonic organ, given in the writer's previous paper (p 16).

35 Application of the Principle of Symmetrical Arrangement to Negative Systems

According to the enunciation of the principle, the positions should, in negative systems, be taken downwards as we ascend in

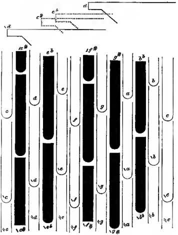
the series of fifths, for the departures thus obtained are negative. But it is practically more convenient to use the positive form in negative systems as well. We speak of this form—in which sharp departures are set off downwards, and flat departures upwards—as the 'reversed' form, in contradistinction to the form used in positive systems, which is spoken of as the 'direct' form.

36. Application of the Principle of Symmetrical Arrangement to a 'Generalised Keyboard' for Regular Systems.

A keyboard has been constructed, on the principle of 'symmetrical arrangement,' in the following manner. The octave is taken = 6 in. horizontally · (in ordinary keyboards the octave is $6\frac{1}{2}$ in.) This is divided into 12 equal spaces, each $\frac{1}{2}$ in. broad, and these are called the 12 principal divisions of the octave. A horizontal line gives the positions of an E. T. series where it crosses them all. The keys are placed at vertical and horizontal distances from the E. T. line corresponding to their departures, on the supposition that the arrangement is positive. The departure of 12 fifths up corresponds to a horizontal displacement of 3 in. from the player, and a vertical displacement of 1 in. up. These displacements are divided equally among the fifths to which they may be regarded as due—i.e., the displacement of *g* with respect to *c* is, $\frac{1}{4}$ in. back, and $\frac{1}{12}$ in. up; so of *d* with respect to *g*, of *a* with respect to *d*, and so on.

Although only 3 in. of each key are thus exposed on a plan, yet the keys are all made to overhang $\frac{1}{2}$ in. · and thus the tangible length of each key is $3\frac{1}{2}$ in.

The accompanying figure (p. 136) shows a small portion of the keyboard, on a reduced scale. The keys are each $\frac{3}{8}$ in. broad, and their centres are $\frac{1}{2}$ in. apart. There is thus $\frac{1}{8}$ in. free between the adjacent surfaces of each pair of keys, and $\frac{2}{8}$ in. altogether between the two keys which rise on each side of any given key. This is of importance; e.g., in the chord *c*—*e*—*g*—*c*, taken with the right hand, the first finger has to reach *e* between the adjoining keys *e*♭—*f*, and under the overhanging *e*. The keys in the five principal divisions which have 'accidental' names (e.g., *c*♯ or *d*♭) are black—the rest white.



37. Application of the Positive System of Perfect Thirds to the 'Generalised Keyboard.'

Helmholtz's System—Just Intonation.

If the thirds such as c–$\backslash e$ are made perfect, and the fifths flat by ·00244, a quantity which escapes the ear, we have the system here mentioned Helmholtz makes a mistake in describing it; (Die Lehre von den Tonempfindungen, Ed. 3, p. 495), he supposes that the fifths are sharp, instead of flat, by the above interval; it is easy to see from the context that this is a mistake.

38. The Small Enharmonic Organ—Positive Stop.

The small enharmonic organ, exhibited when this paper was read, contains a stop tuned according to the last-mentioned system. The compass of the 'generalised keyboard' is 3 octaves, from tenor c to c in alto, and there are 48 notes in every octave. General Thompson's organ, it will be remembered, had 40. Mr. Ellis has pointed out to the writer, that Helmholtz did not employ this system, strictly speaking, but a system of unequally just intonation. The process employed in the enharmonic organ is not, in practice, perfectly equal; but the error is not sensible to the ear. The process is as follows:—The highest note in the series of fifths may be called $_1f$. The eight highest notes on the keyboard are tuned by perfect fifths. At the ninth note, in descending, we have the check $_1f$–d–$_1b\flat$. It is then sometimes necessary to distribute a small error among the fifths already tuned, to get the d perfect, but this is easy; afterwards all the notes are tuned as perfect thirds in triads, and it is found that the notes so tuned always satisfy the condition of making the fifths sensibly perfect. Of course the fifths are not really perfect, but the imperfection is too small to estimate directly; and it appears that in tuning by triads the positions are assigned in the most correct manner possible.

The action is that known to organ-builders as 'direct'—i.e., the stop-sliders run parallel to the movement of the stop-handles, while the grooves of the soundboard are parallel to the front of the instrument. The action is led from the keyboard, by square and tracker work, to a roller-board of four tiers, which extends to a considerable depth back from the keyboard. The rollers are parallel to the grooves, and to the front of the instrument, and are a little longer than the width of the keyboard. By these means the whole series of action is reduced to two long rows of pulldowns, along the two sides of the windchest, and thus every note is easily accessible for regulation, and all the pallets can be got at with ease. This form of arrangement is

susceptible of indefinite extension, and is that which must be adopted in the event of its being desired to build an instrument of the kind with several stops. This plan, the general features of which were devised by the writer, has been most ably carried out by Mr. T. A. Jennings.[1] The keyboard, and the tracker-work, and the roller system specially invite attention by their exquisite workmanship.

39. Improved Screw Stoppers for Tuning Pipes.

The enharmonic organ contains an improvement, also devised by the writer, and carried out by Mr. Jennings. Stopped diapason pipes of metal were selected, as occupying less space than any others; the proverbial difficulty of managing the tuning of such pipes became the subject of consideration, and the screw stoppers here used were devised. The essential feature is, that the stopper contains a moveable slider inside, which is worked by a screw from without. When the stopper is once approximately placed, the body of it never needs to be moved again, and the accurate tuning required for the writer's purposes is easily and conveniently performed by means of the projecting screw.

40. Application of the Notation to the System of 53.

The notation introduced for positive systems (paragraph 9) is susceptible of various accessory rules, according to the system it is attached to. It is required to find rules of identification for passing from one principal division of the octave to another in the system of 53.

Rule.—In the system of 53 the notation becomes subject to the following identifications:—

If two notes in adjoining principal divisions (e.g., *c* and *c*♯) be so situated as to admit of identification (e.g., a high *c* and a low *c*♯), they will be the same if the sum of the elevation and depression marks = 4, unless the lower of the two divisions is black (accidental), then the sum of the marks of identical notes = 5.

This can only be proved by enumeration of a case in each pair of divisions. The mode of verification in any case is the following:—

Noting that the 5-fifths semitone is four units (scheme following Theorem III.) we see that *c*–*c*♯ is four units, whence ////*c*–*c*♯, ///*c*–*c*♯, //*c*–*c*♯ are identities; or, again, *c*♯–*d* is four units, and ////*c*♯–*d*, ///*c*♯–*d*, are identities.

[1] Organ-builder (address at Mr. Fowler's, 127, Pentonville Road). Mr. Jennings has built an ordinary organ for the writer, and also the large enharmonic harmonium.

41. Application of the 'Generalised Keyboard' to the System of 53.

The Enharmonic Harmonium.

The practical studies on positive systems, which the writer has had the opportunity of making, have all been conducted with the assistance of a large harmonium with a very extensive 'generalised keyboard,' containing eighty-four keys in every octave, tuned in accordance with the system of 53. This was also built by Mr. Jennings. It has now been completed about two years. The arrangement is as follows:—

The note $\backslash\backslash\backslash c$ is taken as the first note of the series, and receives the characteristic number 1. Then c is 4, and the remaining numbers can be assigned by the rules for the identifications in the system of 53 given above.

A number of notes at the top of the keyboard are thus identical with corresponding notes in the adjacent principal divisions on the right at the bottom,—e.g. $//c = 6 = \backslash\backslash c\sharp$. These permit the infinite freedom of modulation which is the characteristic of cyclical systems. For in moving upwards on the keyboard, we can, on arriving near the top, change the hands on to identical notes near the bottom, and so proceed further in the same direction, and *vice versâ*. It is to be noted that, in positive systems, displacement upwards or downwards on the keyboard takes place most readily, by modulation between related major and minor key—not, as has been commonly assumed, only by modulation round the circles of fifths. In negative systems, on the contrary, displacements take place only by modulations of the latter type. Suspensions of the harmonic seventh, however, give rise to rapid displacements in both classes of systems.

The keyboard of the harmonium contains seven tiers of levers, the variations in the position of the notes of each tier being determined by the patterns of the keys attached to them. Each of these tiers communicates, through a row of squares, with a row of horizontal stickers. The windchest is vertical, and the valves are ranged on it in seven horizontal rows. The valves have small tails attached, and the stickers open the valves by pressing on the tails. There is no attachment between the stickers and the valves.

The original object of this arrangement was, that the windchest being easily lifted out, another might at pleasure be substituted, containing a different system of tuning. The two additional windchests which were constructed were, however, accidentally spoiled, and have never been replaced. The great practical interest of the application of the mean-tone system to the generalised keyboard leads the writer to hope that he may be able, at some future time, to provide an additional windchest for this system.

42. Application of the System of 118 to the 'Generalised Keyboard.'

The 5-fifths semitone is here nine units, and the 7-fifths semitone is eleven units. The major tone (2-fifths tone) is consequently twenty, and the minor tone (10-fifths tone) is eighteen. Hence the notes in the successive principal divisions are alternately odd and even, and the identifications lie in alternate columns. These are not here further investigated, as no practical use has been made of the system. If $c = 1$, $c\sharp = 10$, ${}_1c\sharp = 12$, $d = 21$. It would be possible to construct a keyboard on the principles already explained, which would give complete control over the notes of the system of 118. A portion of such a keyboard would be practically undistinguishable from one tuned to the positive system of perfect thirds, as the error of the thirds of the system of 118 is too small to be perceived by the ear.

43. Notation for Negative Systems.

As negative systems correspond, in the formation of their thirds, to the ordinary usage of musicians (paragraph 7), the notation adopted for the purpose of indicating position in the fundamental series of fifths becomes to a certain extent unnecessary; for in these systems the distinction between $a\sharp$ and $b\flat$ is a true and essential one, and is sufficient, within a certain limited range, without the introduction of the notation marks. These will, however, continue to be occasionally required. For instance, in the case of the harmonic seventh to c, it would be intolerable to have to write it $a\sharp$, and yet this would be its correct designation. It seems better, therefore, to retain the notation to this extent, that wherever it is used it overpowers, so to speak, the meaning of the flats or sharps employed, and denotes derivation in the series of fifths, just as in the case of positive systems; we can then write the above note ${}_1b\flat$.

In the application of the keyboard to negative systems, a sharp always signifies the higher on the board of the two notes, between which choice may be made; and it must be remembered that the higher on the board is, in this case, the lower in pitch. But whenever the notation appears, it overpowers the above rule, and acts precisely as in positive systems.

44. Application of the Negative System of Perfect Thirds (Mean Tone System) to the 'Generalised Keyboard.'

Small Enharmonic Organ—Negative Stop.

If the thirds such as c–e are made perfect, and the fifth ·05376 (or a quarter of a comma) flat, we have the mean-tone

system. The forms on the keyboard of scales and chords in negative systems are different from those in positive systems. The scales are very easy to play, and the chords also. It is expected that this application may prove of practical importance. By the employment of reversed symmetrical arrangement, we can use the same keyboard as that for positive systems.

Following the scale of unmarked naturals on the plan of the keyboard, we can realise the nature of the fingering. It is the same as that of the Pythagorean scale with the system of perfect fifths on the keyboard. The tones are all 2-fifths tones, and the semitones both 5-fifths semitones.

The small enharmonic organ exhibited to the Association contains, on the three lower tiers of its keyboard, a second stop, the pipes of which are tuned to the above system. It may be regarded as a great extension of the old unequal temperament—that is to say, the performance everywhere produces the same results as if the best chords of the old unequal temperament were employed

45. Application of the Negative System of 31 to the 'Generalised Keyboard.'

The objection to the last-mentioned arrangement (mean-tone system) is, that a certain rather considerable amount of modulation would carry the performer beyond the limits provided; this may be overcome by substituting for the mean-tone system the Huyghenian system of 31, the intervals of which differ very little from those of the mean-tone system The thirds, instead of being perfect, would be ·00783 sharp, or considerably less than the 100th of a semitone, and the fifths ·05181 flat, instead of ·05376; difference = ·00195, or about the 500th of a semitone.

The application of the principles of symmetrical arrangement (reversed) to the numbers of the series of 31 is easily deduced from the table of the numbers of units in the intervals of that system The five tones of any scale consist each of five units—the two semitones each of three It is only necessary to remember, that the lower numbers of the series always stand above, and the higher numbers of the series below, in each principal division of the octave, according to the definition of a 'reversed' symmetrical arrangement

46. Tuning.

It was the writer's intention to have introduced at this point an essay on certain improved methods of tuning These will depend mainly on the employment of an extremely accurate form of metronome, devised many years ago by Scheibler,[1] for the

[1] The Scheibler metronome was exhibited at the meeting, finished all except the graduation It has been constructed for the writer by Messrs. Tisley & Spiller, 172, Brompton Road

counting of beats. On account partly of the difficulty experienced in getting the metronome constructed, and also of the extent of the subject generally, it is preferred to treat it at some future time in a separate communication. An account will be given now only of the mode in which the system of 53 was actually tuned on the harmonium.

The standard *c* was taken to have 512 vibrations per second; this was obtained by comparing several Philharmonic forks professing to have this pitch. Although these agreed sufficiently well with each other, it appeared, subsequently, that the resulting *c* was not satisfactorily derived, and much inconvenience was experienced during the tuning from this cause. The processes then within reach were not sufficiently accurate for a perfect independent determination of the standard pitch. It will be seen, when the subject of Tuning is treated, that an independent determination of this element is always necessary; and this can be made with great accuracy by means of a few pipes or reeds, and the improved metronome.

It was first necessary to produce a set of 53 reeds of approximate accuracy, for the guidance of the builder. A small tuning-machine was constructed, which contained an organ-bellows and two windchests—one for 12 organ-pipes, the other for 12 harmonium reeds. The pipes were fitted with caps and handles to facilitate the tuning. But it was at once discovered, contrary to expectation, that the process of tuning the reeds was far more delicate, certain, and easy than that of tuning the pipes; and accordingly the pipes were never used at all. A table was then calculated, showing the number of beats per minute that must be made by each consecutive pair of notes of the system of 53, in the tenor octave. A set of reeds was then tuned by this table, the beats being counted with a watch, and the practically perfect fifths of the system employed as checks. A very fair result indeed was obtained in this way with but little difficulty. But the following weak points prevented the adoption of the process as an exact one:—

In the first place the counting of the beats by the watch proved an extremely troublesome and rather inaccurate method. This must be replaced by the improved metronome.

Secondly, as the reeds were tuned on the machine, when they came to be removed, and placed on their seats in the harmonium, they underwent small alterations; and although the result on the machine was pretty good, it was no longer sufficient when the reeds were transferred.

Another process, of a more delicate nature, was therefore adopted, by which the dependence on the counting was minimised. This was also first carried out on the tuning-machine; and, before explaining the process, it will be well shortly to describe the arrangement of the machine, as far as the reeds are concerned.

The reed windchest consists of a box, which receives the wind from the bellows through an aperture closed by a valve moveable

from outside On the top of the box the lid fits air tight; it opens on hinges, and is fastened down, when closed, by two handscrews; it can be opened or closed in a few seconds. The lid is pierced by slits, outside which are small valves, and handles for opening the valves; and about the end of the slits there is, inside the lid, a peculiar arrangement of winged screws, of a form which can be got from any ironmonger: these enable any reed to be firmly secured over one of the slits in a few moments. It is essential that the pressure of the screws shall not seriously deform the case of the reed. If this happens the pitch is altered. It is easy to test whether this happens, by tuning two reeds to a fifth, which is the most sensitive interval, and then screwing down one of them a little tighter; the slightest alteration of pitch is an indication that the screws are in fault. Stout handscrews were first employed; and it was not for some time that the considerable error they caused was detected. No results of any value could be obtained with them. The chief practical point appears to be to have the screws as near as possible to the corner of the reeds. When the lid of the box is turned over, the reeds are before the tuner, as if fixed on a table, in a convenient position for the use of the tools. The box is about 2 feet long, 4 inches broad, and 2 inches deep. The small dimensions facilitate the production of difference tones, and these are heard with great clearness. The following scheme for the system of 53 depends on difference tones, and accordingly it was executed with ease on the machine.

One point which must be noted before passing to this is, the pitch of reeds varies very considerably with the strength of wind employed. It is therefore found best to do away with the use of the bellows-valve altogether, and use light pressures on the bellows. It is always possible to find out whether a reed is too high or too low; for if the slit-valve over the reed is partially closed, its pitch falls, and it can be perceived whether the beats get better or worse.

In the system of 53 the fifths are taken to be perfect. The thirds, however, are perceptibly flat. If a major triad is sounded, the displacement of the third gives rise to displacements in opposite directions of the difference tones formed with the other notes; and it was by the beats of these displaced difference tones that the thirds were tuned, in the first part of the bearings. These thirds were tuned either in the position $c_2 - {\setminus}e_2 - g_2$ (between fifth and fundamental), or in the position $g_1 - c_2 - {\setminus}e_2$ (above a fourth). The beats in the latter case are half the number of those in the former, as in the latter only one of the difference tones is displaced by the error of the third. If the position were ${\setminus}e_1 - g_1 - c_2$, the particular beats to be observed would not arise at all. The principles explained in paragraph 27 suffice for the calculation of the numbers required.

The first part of the following system of bearings was carried out with ease on the tuning-machine; but when it was repeated on the harmonium, it was found that the difference tones were so

faint as only to be heard with difficulty, no doubt owing to the great size of the windchest. The method is not, therefore, recommended for adoption in such cases. With the class of pipes employed in the small enharmonic organ the difference tones are strong, and this method might be expected to be successful:—

Bearings of the System of 53.

$c_2 = 4 = 512$ vibrations.

First Part

Tune from	Fourth or Fifth.		Third Flat.	Beats per minute
c_2 4	f 26		\ a_2 43	42
\ a_2 43	\ d_2 12		\ $f_2\sharp$ 28	66
\ $f_2\sharp$ 26	\\ b_1 61		\\ $d_2\sharp$ 15	66
\\ $e_2\flat$ 15	\\ $a_1\flat$ 37		\\\ c_2 / b_1 } 1	48
/ b_1 1	/ e_1 23		/ $g_1\sharp$ 40	40
/ $a_1\flat$ 40	/ $e_2\flat$ 16	check	c_2 4	60

We thus return in a circle to the standard c_2 even without counting the beats, we can easily distribute the small error amongst these few steps, so that it shall be nowhere prominent. In fact, this is a less difficult process than laying the bearings of the ordinary equal temperament. In counting the beats, it is only necessary to notice beforehand what the pitch of the difference tone will be; by sounding this note lightly first, so as to direct the attention to it, it is easy to separate its beats from those of the tierce and the others present, if the difference tones are of sufficient strength to be heard at all. We then proceed to fill up the gaps with perfect fifths, distributing any error amongst the six or seven fifths of each gap:—

Second Part

Bearings of the System of 53.

Tune from	Fourths or Fifths				
f_2 26	$b_1\flat$ 48	$e_2\flat$ 17	$a_2\flat$ 38	$d_2\flat$ 8	} Distribute
\ a_2 43	\ e_2 21	\ b_1 52	—	$f_2\sharp$ 30	} any error
\ d_2 12	\ g_1 34	\ e_2 3	\ f_2 26	\ $b_1\flat$ 47	}
\ $f_2\sharp$ 26	\ $c_2\sharp$ 7	\ $a_2\flat$ 36	—	\ $e_2\flat$ 16	}
\\ b_1 61	\\ e_1 20	\\ a_1 42	\\ d_2 11	\\ g_2 33	}
\\ $e_2\flat$ 16	\\ $b_1\flat$ 46	\\ $f_2\sharp$ 24	—	\\ c_2 2	}
\\ $a_1\flat$ 37	\\ $c_2\sharp$ 6	\\ $f_2\sharp$ 28	—	\\ b_1 50	}
\\\ c_2 1	\\\ g_2 32	\\\ d_2 10	\\\ a_1 41	\\\ e_2 13	}
/ e_1 23	/ a_1 45	/ d_1 14	/ g_2 38 }		
/ $e_2\flat$ 18	/ $b_1\flat$ 46	/ f_2 27	/ c_2 5 }		
/ $a_1\flat$ 40	/ $c_1\sharp$ 9	/ $f_2\sharp$ 31	—	b_1 53	}
c_2 4	g_2 35	d_2 13	a_2 44	e_2 22	}

This process was gone through many times on the harmonium, after all the reeds were in position. The alterations that appeared

at first to take place in the reeds in a few days, were considerable, and it was not for some time that it was perceived that it was the action that was in fault, and not the reeds; small variations in the action affect the pitch of the reeds considerably. But since the source of these disturbances was realised, the reeds have been left alone, and on screwing up the action again at any time, the tuning has always been found to leave little to be desired. Two years have elapsed since the reeds were last touched, and about a year since the action has been touched; and the instrument is now in first-rate order.

47. The tuning of the principal negative system (mean-tone or mesotonic system, negative system of perfect thirds, extension of old unequal temperament) was performed as follows on the small enharmonic organ. Starting from the lowest middle *c* (\c) on the keyboard, \g was tuned temporarily a perfect fifth, and then \e accurately a perfect third; \g was then flattened a little, and \d and \a tuned successively a little lower than consonance would require. Check, \a – \e must be a fourth or fifth of the same quality with the others. After a little practice this was easily carried out. Every succeeding set of 4 fifths was tuned in the same way, checking always by a third tuned in a perfect triad.

48. Higher Approximations.

For an outline of the theory of multiple systems, and of certain systems of higher orders, which are not of much practical interest, reference is made to the writer's paper on 'Temperament,' in the current volume of the Proceedings of the Royal Society.

49. Complete Symmetrical Arrangement.

This form of higher approximation is of some interest, as admitting of a very clear representation of the accurate relation between perfect fifths and thirds—also as introducing a form of symmetrical arrangement, which, although the most complete, is also the most simple in its origin.

Let a series of E. T. notes be placed, in order of the scale, at equal distances on a horizontal line; if we represent each note by a dot, we shall have one of the horizontal rows of the table at page 16. Let other E. T. scales be placed above and below the first, each note of each successive row being higher than the corresponding note of the next row below by the departure of a perfect fifth (= 01955). Then we have a symmetrical arrangement of perfect fifths, with all the positions filled up—*i.e.*, between *c* and /*c* there are 11 notes and 12 intervals, each = 01955. Now \e was the third got by 8 fifths down, and it is a little too

low. If we take the *e* which is seven steps below the E. T. row containing *c*, instead of that which is eight steps below, we obtain a third the error of which is little more than ·00001, or one hundred-thousandth of an E. T. semitone. In fact,—

Departure of seven fifths	=	·13685 00606
" third	=	·13686 28614
error		·00001 28008

carrying the calculation to ten places. By adjusting the exact value given to the difference between the rows, it is possible to get the approximation more exact, but this is of no material interest. It would be possible, if desired, to construct a keyboard for such a system, the dots of the figure of paragraph 13 being replaced by concertina-keys. It would then be possible to play fifths and thirds perfect to the above degree of approximation.

50. Application of Regular Cyclical Systems to Complete Symmetrical Arrangements.

[The matter of the following section was suggested by the discussion of the properties of the system of 612, the importance of which was pointed out by Captain J. Herschel, F.R.S., to Mr A. J. Ellis, F.R.S., and by him to the writer.]

In order that any Regular Cyclical System may be applicable to a complete symmetrical arrangement, it must be a multiple of the ordinary equal temperament, or *n* must be divisible by 12.

For the essence of a complete symmetrical arrangement is, that it may be regarded as made up of a number of E. T. systems, each of which is represented by a horizontal row of the symmetrical arrangement. (See p. 16.)

Any system which is a multiple of the equal temperament may be also regarded as of the 12th, 24th, . . . order. This follows at once from the Theorems on the orders of systems.

To find a cyclical system which shall possess in all its parts the properties of the complete symmetrical arrangement above described:—

The departure of the perfect fifth may be written $\frac{1}{51\cdot151}$, and the system sought must have fifths closely corresponding with his in departure. If *r* be the order of the system, we have then $\frac{r}{n} = \frac{1}{51\cdot151}$, or $n = r.\ 51\cdot151$ approximately, where *r* and *n* must both be multiples of 12. Let $r = 12$. Then the best value of *n* is 12×51, or 612. The fifths of this system have the departure $\frac{1}{51}$. Error = 000,058 sharp. The thirds, being formed, according to the rule for complete symmetrical arrangements, by seven steps down instead of eight, have the departure $\frac{7}{51} = -\frac{8}{\frac{8}{7}51} = -\frac{8}{58\cdot286}$. Error = ·000,39 flat.

It is easy to see, from the correspondence of these errors, that they may be much diminished by making the fifths more perfect.

The next higher value of r, which gives any considerable approximation applicable to complete symmetrical arrangements, is evidently 240, since $240 \times \cdot 15 = 36$. Then $n = 240 \times 51 \cdot 15 = 12{,}276$.

The departure of the fifth is $\frac{1}{51\cdot15}$. Error = 3 in the seventh place of decimals; and error of the third = a unit in the fifth place.

51. Practical Use of Positive Systems.

An example of music written for positive systems is appended, as well as a short cyclic modulation in the system of 53 (pp. 151–154). This last can be played on the harmonium, but not on the small enharmonic organ. The principal points in the harmony of these systems which have struck the writer occur in the example. It is to be specially noticed how certain forms of suspension have to be avoided—partly because they produce dissonances, partly because they occasion large displacements up and down the keyboard. The result of the writer's practical experience is, distinctly, that there are many passages in ordinary music which cannot be adapted with good effect to positive systems; and that the rich and sweet masses of tone which characterise these systems, with the delicate shades of intonation which they have at command, offer to the composer a material hitherto unworked. The character of music adapted for these systems is that of simple harmony and slow movement; it is a waste of resources to attempt rapid music, for the excellence of the harmonies cannot be heard. The mean-tone system is more suitable for such purposes.

Some examples of the unsuitability of the positive systems for ordinary music may be here instanced.—

(1.) The opening bars of the first prelude of Bach's 48. The second bar involves the depressed second (⌄d), and in the third bar this changes to d; the melodic effect is extremely disagreeable on the harmonium. It does not strike the ear much with the stopped pipes of the little organ.

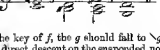
(2.) The example of cyclical modulation at page 154, the harmony of which is extended from a passage in the second prelude of Bach's 48.

The effect of this is not bad when one is accustomed to it; but it alters the character of the music completely, and is very disagreeable to unaccustomed ears.

(3.)

The two g's, to which attention is here called by asterisks, illustrate a difficulty of constant occurrence in the adaptation of ordinary music to these systems. The g is here required to make a fourth to the depressed second of the key ($\searrow d$), and also a fifth to the keynote. But the first condition requires the note $\searrow g$, the second g, and it is impossible to avoid the error of a comma somewhere. It may be said that the first g is only a passing note; but with the keen tones of the harmonium such dissonances strike through everything, even on the least emphasised passing notes. Although the second g seems to the writer to be legitimate, it would be intolerable on the harmonium. The smoother tones of the organ render such effects less prominent.

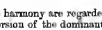
(4) The third phrase of a well-known chant:—



To keep in the key of f, the g should fall to $\searrow g$ at the second chord; but this direct descent on the suspended note would sound bad—consequently, the whole pitch is raised a comma at this point by the suspension; and the chant concludes in the key of $\nearrow f$, as it is not possible anywhere to descend again with good effect This would be inadmissible in practice, as the pitch would rise a comma at each repetition. The resources of the system of 53 admit of the performance of the repetitions in this manner, but the case is one in which the employment of this effect would be unsuitable.

On the organ it might be possible to take the last chord written above $\searrow g - \searrow d - \searrow g - b\flat$, which would get rid of the difficulty. On the harmonium, however, this drop from the minor chord of g to that of $\searrow g$ is inadmissible.

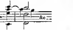
In the example of music written for the positive systems, it is to be noted that the notation-marks are used as signatures, exactly as flats and sharps are in ordinary music. The sign adopted for neutralising them is a small circle (○), which is analogous to the ordinary natural. If the general pitch had to be raised or depressed by a comma, the elevation or depression mark would be written large over the beginning of the staff:—



Several points in the harmony are regarded as experimental. For instance, in the inversion of the dominant seventh with the seventh in the bass, the employment of the depressed (harmonic) seventh has on the harmonium an odd effect; although, when the chord is dwelt on, it is heard to be decidedly smoother than

with the ordinary seventh. The effect appears less strange on the organ On this and other points the judgment of cultivated ears must be sought, after thorough acquaintance with the systems.

The following points may be noticed in the example —

At the beginning of the seventh bar it would be natural, in ordinary music, to suspend the *a* from the preceding chord, thus :—

As, however, the first *a* is ╲*a*, and we are modulating into *g*, whose dominant is *d*, the suspension is inadmissible, as it would lead to the false fifth *d* – ╲*a*.

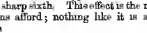
In bar 14 the ordinary seventh ╲*d* to dominant ╲*e* is employed in the bass instead of the harmonic seventh ╲╲*d*, so as to avoid the small tone ╲╲*d* – *c* The latter has a bad effect in the minor key, as before noticed, and this is specially marked in the bass

Bar 19 —The use of the tonic as first note in the bass is prevented by the presence of the harmonic seventh on the dominant (paragraph 30).

Bar 24.—This singular change is pleasing in its effect when judiciously used, but it is advisable to separate the two forms of the chord by a rest

Bar 30.—The smoothness of the approximate harmonic seventh is here applied to the sharp sixth This effect is the most splendid which the new systems afford; nothing like it is attainable on ordinary instruments

Bars 34 *and* 35 —Here the natural course would be to make the bass :—

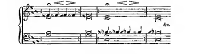


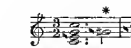
the harmony remaining the same. We have, however, arrived at our *d* as the fifth to *g*, and it is not possible to suspend it unless we raise the ╲*a* to *a* It has not a good effect where a passage is repeated as here, if the repetition is in a slightly different pitch The suspension is therefore avoided.

Bar 37.—This is a very charming effect. The transient modulation to dominant *d* gives the depressed keynote, ╲*c*, as harmonic seventh.

52. Comma Scale

The following is an example of a novel effect which is attainable in positive systems If the chord of the harmonic or natural

seventh be sustained, this seventh may be made to rise and fall again through two or more single commas. The effect to unaccustomed ears is disagreeable at first; but the writer has become so familiar with these small intervals, that he hears them as separate notes without the sensation they commonly produce of being one and the same note put out of tune There can be no doubt that the reception of such intervals is a question of education, just as the reception of semitones was, in the early history of music, a step in advance from the early five-note scales The following passage, as executed on the enharmonic harmonium, which admits of a swell of the tone, has a dramatic effect.—

53. Series of Major Thirds



The chord to which attention is called consists of two perfect thirds and the octave. The third \\g♯ — c has a departure due to 16 fifths up, and an error from the perfect third of about two commas It may be called the 'superdissonant' third, by analogy from the dissonant or Pythagorean third, which has an error of one comma We have the choice, if we prefer it, of arranging the chord with two dissonant thirds, thus:—

c — *e* — *g*♯ — *c*.

The two last thirds are ordinary dissonant thirds; the writer prefers the first arrangement It is a matter of taste

The examples were played on the positive stop of the small enharmonic organ, at the meeting of the Association.

54. Mean Tone System.

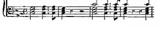
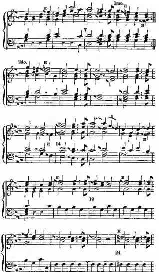
It has been pointed out, that the generalised keyboard admits of the control of negative systems by means of remarkable simplicity. Not only is the fingering very simple, but the sharps and flats of ordinary music furnish indications, the inter-

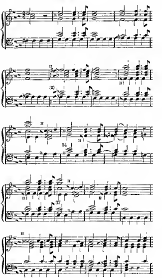
pretation of which is clear, the finger going up for the sharp and down for the flat. Although the mean-tone system, on the small organ, was completed only just in time for the meeting of the Association, yet the writer succeeded, at some pains to his ears, in studying the mechanism of that system, to a small extent, on the keyboard of the 53 harmonium. The effect of playing on that instrument in negative form is, of course, to use Pythagorean thirds; and, in consequence, the writer may probably claim to have a greater practical acquaintance with the Pythagorean system than anyone else is likely to possess. The effect is not such as to lead to a desire for its adoption. The examples selected for performance were the first, second, and 33rd preludes of Bach's 48. The fugues were found impracticable, on account of the want of the lower octave; this does not cut so deeply into the preludes selected as to prevent their performance. These three examples were played on the mean-tone stop of the small enharmonic organ at the meeting.

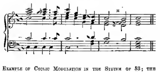
CONCLUSION.

In the foregoing communication the endeavour has been made to give a simple and general theory of the division of the octave, to provide a system of notation by which the notes of different systems can be expressed for practical purposes, and to solve the mechanical problem for keyed instruments. It may be now affirmed that there is nothing whatever, except study, necessary to enable anyone to obtain a practical command of any system that may be desired; and it is believed that the difficulties of that study have been reduced to a minimum.

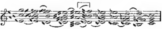
EXAMPLE FOR SYSTEMS OF APPROXIMATELY PERFECT FIFTHS, WITH A COMPASS OF THREE OCTAVES.

H=Harmonic or Natural Seventh, or inversion thereof.


1mo.
2do.
7
14
19
24


30
34
37

EXAMPLE OF CYCLIC MODULATION IN THE SYSTEM OF 53; THE HARMONIES TAKEN FROM BARS 5 TO 10 OF THE PRELUDE No. 2 OF THE 48 (BACH), TRANSPOSED AND EXTENDED.

Identifications.



DISCUSSION.

The CHAIRMAN said it was extremely difficult even for experts to follow a paper of this kind when read, but when printed in the Transactions of the Society, which were in active preparation, it would no doubt be perused with great interest. There was not much time left for discussion, but if any member wished to put a question he was quite sure Mr. Bosanquet would be pleased to answer

Mr. A. J. ELLIS, F.R.S., F.S.A., said he should like to read the few lines which Mr. Bosanquet had referred to as expressing the opinions of Helmholtz with regard to the cause of beats. 'The roughness of a combination of two tones depends, then, in a compound manner on the magnitude of the interval, and the number of beats produced in a second. On seeking for the reason of this dependence, we observe that, as before remarked, the beats on the ear can exist only when two tones are produced sufficiently near in the scale to set the same elastic appendages of the auditory nerve in sympathetic vibration at the same time. When the two tones produced are too far apart, the vibrations caused by both of them at once in Corti's organs are too weak to admit of their beats being sensibly felt.' Then with regard to the experiment with Herr Joachim, he says: 'I was fortunate enough to have an opportunity of making similar observations, by means of my harmonium, on Herr Joachim. He tuned his

violin exactly with the $g\ d\ a\ e$ of my instrument. I then requested him to play the scale, and immediately he had played the third or sixth, I gave the corresponding note on the harmonium. By means of beats it was easy to determine that this distinguished musician used the depressed b, and not the other, as the major third in G, and the depressed e, and not the other e, as the sixth.'

With regard to the melodic feeling of playing, he might say that the experiments of Cornu and Mercadier, as given in the *Comptes Rendus* (which he had calculated out and reduced to numbers with equal semitones and fractions of them), were so conducted that the pitch was determined by a mechanical process, and not by the ear, so that they might be entirely depended upon. The performers were quite unaware of what was being done, and played as usual; but the result was that in playing harmonies they always used the just intonation, the perfect third and fifth; but in playing melodies they used the intonation, which was supposed to be Pythagorean; at any rate they played the thirds and sixths, and especially the sevenths, sharper than in equal temperament, the seventh being sometimes a comma sharper. He had also observed, in calculating out the numbers, that they seldom played the same interval twice alike, that their fifths and octaves were very frequently changing. In playing the minor scale, on the other hand, the minor third and the minor fifth were taken flatter than they would be even on the Pythagorean method. It was evident, therefore, that the performers had not made up their minds to any particular scale, but they had a general feeling of brightening by taking the intervals sharper, and dulling by taking them flatter; but that when they played harmonies their feeling was to get consonance.

MR. SALAMAN understood that the practical results sought for by these investigations was to ensure more perfect tuning of musical instruments, rather than to have any effect on the composition of music.

Mr. BOSANQUET said his view most decidedly was, that there was a new material for composers to work with.

Mr. MCNAUGHT asked if it were correct to say that existing music could not be performed in just intonation—vocal or instrumental?

Mr. BOSANQUET said much of it could not.[1] No one could execute those small intervals with accuracy by the voice; they could only be examined by an instrument. The voice would very readily adapt itself to the instrumental accompaniment.

Mr. CUMMINGS thought the harmonium (which Mr. Bosanquet had referred to as the instrument by which he had made some of his experiments) was not to be depended upon for anything whatever. It seemed never to give a chord fit to listen to, and therefore he did not think any test of that kind could be relied upon. It gave out so many harmonics that you could not judge of any music fairly by its means.

[1] See paragraph 51 (3), &c.

Mr. Bosanquet said his harmonium had stood perfectly in tune for two years. The reeds were at least twenty times as sensitive as an organ-pipe, and had remained perfectly in tune.

Mr. Cummings remarked that all the harmoniums he had ever tried seemed to give out harmonics more freely than any other instrument. If Mr. Bosanquet's was different in that respect, he should be glad to hear it.

The Chairman observed that the resultant sounds of an harmonium were generally detestable.

Mr. Bosanquet said the great defect in the harmonium was that it was so sensitive to tuning, and that very fact made it so valuable to him in his experiments, because differences which the ear would not detect in another instrument became evident at once on the harmonium. The tuning of an harmonium was far more accurate than that of organ-pipes; you could tune any quantity of the latter from an harmonium, but you could not reverse the process. This fact made it so valuable as a means of research.

The Chairman said he had had the advantage of hearing Mr. Bosanquet's harmonium, and certainly some of the effects were exceedingly beautiful; for instance, its powers were singularly illustrated in a passage commencing the 'Stabat Mater' of Palestrina, which was frequently quoted as an instance of the harshness of the old masters. As Mr. Bosanquet played it, the effect was certainly altogether different—much more delicate, aerial, *spirituelle* than he had ever heard it played. Of course four good singers would unconsciously give the right intonation to it, as was remarked by Burney in his account of the Pope's Chapel, that the singers there unconsciously sing in what is no doubt perfect tune. The point that remained, and the question upon which musicians seemed never to have been satisfied, was whether the mechanical difficulties of obtaining these effects were not so great as to render them useless for practical purposes. As he understood Mr. Bosanquet, this organ required about six times the number of keys and pipes of an ordinary instrument. Now, if the organ of St. Paul's were multiplied by six or seven, it would hardly go under the dome. Besides that, he thought some of the combinations which had been put before them as beautiful were hideous; some of the harmonic sevenths, for instance, were extremely disagreeable.

Mr. Bosanquet said he had always found those notes disagreeable to such persons as had a strong sense of absolute pitch. The only way to like them was to listen to the chords. He never knew anybody who had a good ear who liked them at first.

The Chairman: Then comes the question, what is a good ear, and who has it?

Mr. Bosanquet said he had frequent experience of all sorts of people coming to hear his harmonium, and the result was, that persons with acute ears, but not much musical education, liked the chords, and always picked out the effects which he liked best himself, as the result of long custom; but persons who had the scale

firmly in their heads, as no doubt the Chairman had, did not like the departure from the usual value of the notes. They did not think of the consonance at all; the question with them being, not whether it was smooth, but whether it was what they were accustomed to. The question with him was simply one of smoothness.

Mr. CUMMINGS said the chord of the sixth on A♭, at the beginning of the second page of the example which Mr. Bosanquet played, sounded to him very flat indeed.

Mr. BOSANQUET said that was A♭ *raised*. It was a curious fact, that people with highly-educated ears almost always singled out the true minor third of the chord as disagreeable. The true minor third was always raised.

Mr. A. J. ELLIS thought a few lines from 'Barrow's Travels in China' had some bearing on the point of the ear being accustomed to certain intervals. He said the tones were far from being disagreeable, but their construction was so irregular that they did not appear to be reducible to any kind of scale. He went on to say that the Chinese affected not to like the Ambassador's band, which, they pretended, produced no music, but a confusion of noises. It was a very remarkable fact, to be taken in connection with this, that 2,000 years before Pythagoras (according to the Chinese rules, translated by Amyo), the Chinese had a scale of twelve perfect fifths, producing a complete succession; and that in the year 1537, long before it was dreamed of in Europe, a Chinese prince gave the lengths of a series of organ-pipes, producing theoretically perfect equal temperament.

The CHAIRMAN said it was remarkable that those persons who were generally considered the most highly gifted as composers had all been accustomed to the same kind of tuning, and John Sebastian Bach took the trouble to write, for what was obviously the equal temperament, forty-eight preludes and fugues in the different keys. No doubt the present system was theoretically wrong, but it was one which satisfied Mozart, Beethoven as long he could hear, and many others, including all the great singers.

Mr. BOSANQUET desired to remark that he had never advanced the position that the ordinary scale was wrong.[1] No doubt it was perfectly good in practice, and very few, probably, used it more than he did himself, as an amateur. His contention, however, was, that the theory of music, regarded as a science, had not been at all developed. Nothing was known, theoretically, of the different modes of dividing the octave, and he considered such a state of ignorance to be a scandal to musical science. This had led him to make experiments. He believed that now a new material for musical composition had been provided, but that was quite a secondary consideration.

Mr. ELLIS observed that Handel used the mean-tone temperament, and presented an organ to the Foundling Hospital with sixteen notes in the octave.

[1] Except, of course, from the tuner's point of view.

The CHAIRMAN said he might venture to repeat a remark he had made on the previous occasion, that if Herr Joachim played in perfect intonation, theoretically, how could he play with a piano, which was of course a perfect mass of cacophony?

Mr. ELLIS said he would, of course, alter his intonation so as to be in tune with the piano, as was shown to be the case in the experiments of Cornu and Mercadier. He had noticed the same thing himself in listening to the Paris Prize Choir of Tonic Sol-faists. They sang some pieces without accompaniment, and some with, and the intonation was as different as light and darkness.

The CHAIRMAN remarked that one of the inconveniences of perfect intonation would be, that you would continually leave off on a different keynote to that on which you began, so that the old test of sinking in pitch for singing out of tune must be entirely fallacious.

Mr. ELLIS said that Smith, in his 'Harmonics,' quoted the case of a monk who had reckoned up that the choir must have gone many commas out of tune; and argued, therefore, that there was an involuntary temperament used by singers, which he believed to be the case.

Mr. BOSANQUET said, Smith established it as a proposition,[1] that in performance by violinists or singers, there was nothing in the way of an accurate rule of any kind, but there was a constant process of adjustment, by which all difficulties were got over.

The CHAIRMAN: Art—not science.

The proceedings were concluded by a vote of thanks to Mr. Bosanquet.

[1] Smith's *Harmonics*, Prop. xxi. p. 225

JUNE 7, 1879

R. H. M. BOSANQUET, ESQ., M.A., F.R.A.S., F.C.S., FELLOW OF ST. JOHN'S COLLEGE, OXON., IN THE CHAIR.

ILLUSTRATIONS OF JUST AND TEMPERED INTONATION.

By ALEXANDER JOHN ELLIS, ESQ., B.A., F.R.S., F.S.A.

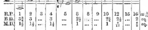
MR. ELLIS commenced as follows:—'By *intonation* is here meant a selection of musical sounds of certain degrees of pitch, made according to some fixed principle. It is called *just*, when that principle is to make the consonances as perfect as possible. It is called *tempered*, when the degrees of just intonation are slightly altered, with a view of materially facilitating performance on instruments having fixed tones, and, since the introduction of harmony, with the intention of injuring the consonances as little as may be compatible with that facilitation. That is to say, just intonation prefers harmony to manipulation—tempered intonation prefers manipulation to harmony. To understand this distinction thoroughly, and the various contrivances that have been proposed for serving at once the muse and the instrumentalist, it is necessary to know on what consonance and its deterioration depend. This requires a knowledge of the nature of musical sound itself, such as has been collected and clearly explained, within the last thirteen years, by Professor Helmholtz. But the results may be readily felt and appreciated by simply hearing a few experiments and harmonies. It seemed to me, therefore, that I should be rendering a service to the Musical Association if I showed a few of the elementary experiments in a manner which anyone could reproduce for himself, and also exhibited the effect of the principal tempered intonations, as contrasted with the just, in the chief forms of harmony. In doing so, I shall endeavour to reduce my observations to the merest thread sufficient to string my illustrations together, and refer those who wish to enter fully into the subject to my translation of Professor Helmholtz's work on the *Sensations of Tone*.'

Mr. Ellis then proceeded to show simple tones, by the resonance of jars of air to tuning-forks; and illustrated the first great law affecting intonation, or *the law of beats*—namely, 'that *simple* tones forming less than a certain interval with each other will beat, and that these beats will produce a maximum dissonance at from one-third to five-twelfths of that interval.' According to Professor Mayer's late complement to Professor Helmholtz's law, the 'beating distance' is the number of equal semitones marked

B D,[1] and the interval of 'maximum dissonance' is the number of equal semitones marked M D for different pitches in the diagram on p 161, where R P indicates the relative pitch of the notes, supposed to be simple tones, which, when multiplied by 64, gives the absolute numbers of vibrations in one second for the notes written over them, in just intonation The second great law affecting intonation, or the law of differentials—namely, 'that two simple tones, sounded loudly enough to make the excursions of the particles of air bear a sensible ratio to the length of the wave, produce a third tone, having for its vibrational number the *difference* of the vibrational numbers of the generators'—be illustrated by two piccolo flageolets playing the G which is four octaves above the lowest note on the violin, and the F sharp next to it, and producing the low G (or more nearly the F below it, on account of the faulty intonation of these instruments) as the 'differential tone' Such tones are also simple, and obey the first law.

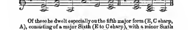
The third great law affecting intonation, or the law of composition of musical tones, is that which forms the great feature of Professor Helmholtz's work—namely, 'that all musical tones are heard as if they were produced by a series of simple tones having the relative numbers of vibrations 1, 2, 3, &c., of very various degrees of loudness, sounded together' In the diagram on p 161 the columns show the relative pitches of the 'partial tones' which compose a 'compound musical tone,' for pitches of their 'lowest partials,' or 'primes,' corresponding to the notes at the head of the column The loudness of the primes in each is generally much greater than that of any one of the partials For the bass tones on harmoniums, Mr. Ellis showed that as many as sixteen at least of these partial tones are quite effective. By combining two musical tones together, such that the pitch of the prime of one corresponds to the pitch of a partial in the other (as any two or more in the diagram), the partials of each, and also their differential tones, will either fit in successively as partials of the lowest tone (in the first column), or coincide, and thus augment the power of certain partials, producing new 'artificial qualities of tone'—that is to say, 'chords' If the partials strengthened lie within the 'beating distance' of one another, and especially lie near the interval of 'maximum dissonance,' the effects even in this case will be more or less rough, according to the pitch of those tones The intervals 8 : 9, 9 : 10, 15 : 16, 24 : 25 become most important in producing these beats. Thus even Fifths, when taken low enough in the bass, beat strongly with 8 : 9 and 9 : 10 The tones combined in just intonation have always such relative pitches as those described. In

[1] These results were published by Professor Mayer in April 1874. In May 1875 he showed that very sensitive ears are capable of hearing beats at intervals nearly one semitone wider But the intervals of maximum dissonance remain as those marked M D, and are even smaller intervals for many ears. The results vary much from individual to individual, but the diagram gives a good average.

tempered intonation the pitch of one or more notes is slightly altered (but by not exceeding the ratio of 80 to 81, or a comma), and the consequence is that the partial tones which do not beat, do not fit into the series of partial tones requisite to form a musical artificial quality of tone, and those partials which ought to coincide are always within the interval of maximum dissonance, and hence more or less rough and annoying.

R.P.	1	2	3	4	5	6	8	9	10	12	15	16	in $\frac{1}{64}$ sec.
B.D.	$3\frac{3}{4}$	3	...	3	...	$2\frac{1}{2}$	...	...	$2\frac{1}{4}$	$2\frac{1}{5}$	...	2	eq. sem.
M.D.	$1\frac{1}{2}$	$1\frac{1}{3}$	...	$1\frac{1}{4}$	...	1	...	..	1	[illegible]	...	[illegible]	eq. sem.
	1												
	2	2											
	3	...	3										
	4	4	...	4									
	5	...	..	...	5								
	6	6	6	...	...	6							
	7												
	8	8	...	8	...	...	8						
	9	...	9	...	...	...	...	9					
	10	10	...	...	10	...	...	...	10				
	11												
	12	12	12	12	...	12	...	...	...	12			
	13												
	14	14											
	15	...	15	..	15	...	...	...	...	...	15		
	16	16	...	16	...	...	16	...	...	...	...	16	
	17												
	18	18	18	...	...	18	...	18					
	19												
	20	20	...	20	20	...	.	...	20				
	21	..	21										
	22	22											
	23												
	24	24	24	24	...	24	24	...	...	24			
	25	...	...	...	25								

This law and its consequences were illustrated by simple tones struck with compound tones, by the compound tones of a common harmonium tuned with the relative pitches in the diagram, but with power to alter the pitch of one note by a comma (as described in Mr Ellis's translation of Helmholtz, p 681), and by four concertinas tuned in Greek (including Arabic) mean, equal, and *just* intonation By means of these Mr. Ellis was able to compare the effect in these different intonations of Fifths, Fourths, Thirds, and Sixths, and also to play and compare

the six best forms of the major and three best forms of the minor triad of A according to Helmholtz, namely :—



Of these he dwelt especially on the fifth major form (E, C sharp, A), consisting of a major Sixth (E to C sharp), with a minor Sixth (C sharp to A) superimposed, and an Eleventh (E to A) between the extreme tones. He showed that this form was quite smooth in just intonation, was very little disturbed in mean and Arabic intonations, but was frightful in Greek and equal intonations. And he showed that this arose principally from the beats of the differential tone of the Eleventh (E to A), which beat with middle note (C sharp), and that of the major Sixth (E to C sharp), which beat at the same rate with the lowest note (E), and hence that it was independent of the quality of tone employed. Similar remarks applied to the first chord. The third and fourth chords also afforded examples of beats arising from differential tones. He also played a complete major scale, harmonised without discords, in all the different intonations, and a short chorale (also harmonised without discords, but introducing minor chords and slight modulations) in just, mean, and equal intonations, to show the difference of the effects, especially for the last three intonations, which are those with which music is at present principally concerned.

Mr. Ellis concluded as follows :—'Intonation has always been considered as of the utmost practical importance, because it affects the sound of every chord struck. Just intonation gives a gradation from perfect consonance to intense dissonance, unattainable strictly by any temperament, and especially unattained by equal temperament, which cannot produce a single triad without conspicuously dissonant beats, on any qualities of tone suitable for sustained musical expression, such as those of the voice, bowed or reed instruments.

'The history of temperament may be condensed into a few sentences. The Greek intonation was perfect for melody, and impossible for harmony, as even the Greeks themselves acknowledge that all its thirds were dissonant. Down to the eleventh century the Greek intonation influenced everything. Guido d'Arezzo then exercised his pupils by the monochord, presumably in just intonation, which offered no theoretical or mechanical difficulties as long as modulation was confined to passing from the key of C major to those of F and G major, or, provided the dominant chords were left minor, into A and E minor. It was not till the middle of the sixteenth century when either Salinas or Zarlino (for they dispute the honour) invented the mean-tone

temperament, that it became possible for the organ to modulate into B flat, and into G and A major, and into A minor, with partial effects of D and even G minor, all with major dominants. But the wheel of modulation once started, it could not stop here. C minor and F minor, and E major and E flat major soon became indispensable. The organist then struck G sharp for A flat, and so on, and produced those howlings which soon gained the name of "wolves," and wondrous efforts were made to avoid them. At last Sebastian Bach, in the middle of the eighteenth century, adopted an expedient previously suggested, and *sharpened his major thirds*. Finally, his son Emanuel, in 1753, announced his "wohl temperirtes Clavier," his "well-tempered clavichord," which became the parent of our present (intentionally) equally-tempered pianoforte, and it is to the peculiar adaptability of the tones of this instrument for disguising the defects of such a method of tuning that the general acceptance of that temperament is probably due. On the organ the shortcomings of this intonation were too manifest for them to be at once accepted as satisfactory, and the long struggle between the old organ-tuning and the new is not yet quite over. The great organ of St. George's Hall, Liverpool, built so lately as 1855, was tuned to the mean-tone temperament, and it was not till 1867 that it was re-tuned in equal temperament, for the purpose of playing with orchestras. (*Choir*, 27th February, 1875, p 131.) Equal temperament, or what tuners give us for it (a very different thing, generally), has indeed become a temporary necessity. If we will play no more than twelve sounds in an octave, we cannot avoid the fearful "wolves" in certain keys, now rather favoured, without introducing minor "wolves" in every key. But the discoveries of Helmholtz have sounded the knell of equal temperament, which must henceforth be recognised as a theoretical mistake and a practical makeshift—a good servant dismissed for becoming a bad master, and now merely retaining office till his successor is installed. The human voice, the violin, and the trombone do not require it, and will enable the composer to study the wondrous wealth of just intonation as a means of musical expression, when the laws of just modulation have been laid down. After Helmholtz's discoveries, they become comparatively easy to formulate, and in an Appendix to my translation of his work, I have endeavoured to follow out the hints he has given. There is really no theoretical difficulty left, either in notation, or the relations of tone, or the mechanical production of the notes required. For vocal execution just intonation is rendered easy by a constant reference of every sound to a known tonality, provided singers eschew the piano. For bowed instruments the same feeling cannot but lead to the same result, and similarly for trombones, because the ear so readily perceives and rejects the intrusion of inexact tones in harmony. Mr. Bosanquet's fingerboard enables even organs and harmoniums to produce practically just intonation. I am unable to speak as to the wood and other brass of the orchestra But they must certainly follow the lead, or

be left out of the race. At any rate just intonation, even upon a large scale, is immediately possible. And if I long for the time of its adoption, in the interests of the listener, still more do I long for it in the interests of the composer. What he has done of late years with the rough-and-ready tool of equal temperament is a glorious presage of what he will do in the future with the delicate instrument which acoustical science puts into his hands. The temporary necessity for equal temperament is passing away. Its defects have been proved to be ineradicable, because inherent in the nature of sound. An intonation possessing none of these defects has been scientifically demonstrated. It is feasible now on the three noblest sources of musical sound,—the quartet of voices, the quartet of bowed instruments, and the quartet of trombones. The issue is in the hands of the composer. Can any one doubt the result?'

DISCUSSION.

MR. AMBROSE SMITH asked if the second law enunciated by Mr. Ellis was not incorrectly stated, in representing that the resulting low sound produced by the concurrence of two high tones was that arising from the *difference* in the number of vibrations of the two upper tones? As he understood, it was represented by the *greatest common measure* of the two upper notes. Thus, if these tones were respectively produced by 280 and 360 vibrations, the subordinate sound would be that arising from 40 vibrations. This was laid down in a paper read before the Philosophical Society of Cambridge, some years ago, by Professor De Morgan.

Mr. ELLIS said the subject had been more fully investigated since then by Professor Helmholtz, on whose authority his remarks were based.

The CHAIRMAN said the question of Mr. Ambrose Smith was incontestably answered by the fact that the resultant low sound equally occurred when the number of vibrations of the upper tones were incommensurable. Professor De Morgan's paper was read before the investigations of Helmholtz had been made. With regard to experiments for the production of beats from high notes, he might mention that for some time past he had been in the habit of using an arrangement of small organ-pipes for that purpose. He did not know that he could perform the particular experiment mentioned by Mr. Ellis, but, as far as the production of difference-tones was concerned, they were readily produced by an arrangement of wide-stopped organ-pipes; and by the aid of a little tap in the foot of each pipe, the pitch of the tone could be regulated with the greatest nicety, and with care the difference-tone would almost resemble an ordinary bass-note. He had had some experience in mean-tone tuning, and it showed him that the mean-tone fifth was almost too bad for musical purposes in the treble, though as long as the bass was going it was bearable

The quarter comma was very hard on the fifths, and if you struck a single triad high up in the scale, the beats were heard very sharply and unpleasantly, so that, although the third was perfect, the mean-tone had many disadvantages.

MR. ELLIS, in conclusion, said his main object had been to show how experiments might be made, so as to verify the statements of Helmholtz. His harmonium was tuned by making seven major chords perfect, and by its help almost every experiment needed might be tried. Ordinary tuning-forks, and ordinary jars, tuned with a little water, served to produce the simple tones, and to hear their beats as distinguished from the others. Those who wished really to study Helmholtz's book would find it necessary to have something to guide their ear, for though it was said by Dr Macfarren, that you could hear the right through the wrong, it was very difficult for the majority of people, who never happened to have heard the right.

A vote of thanks was then passed to Mr. Ellis, which concluded the proceedings.

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